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The Conference Board

Keys to U.S. Competitiveness

Business executives, educators, government officals assess the state of:

- *the research enterprise*
- *basic education in science, math*
- *continuing technical training*
- *investment in R&D*
- *commercialization of U.S. technology*

Research Report No. 907

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Keys to U.S. Competitiveness

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A Research Report from The Conference Board

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From the President

One of the most demanding challenges facing America's leadership is to restore the country's competitive position in the global marketplace. If not checked, the pattern of the last 15 years—slowing productivity combined with competition from lower-wage foreign producers—will result in a permanent decline in the U.S. standard of living. Lagging productivity growth reflects, in part, the difficulty U.S. industry has had in moving new technologies from the laboratory to the marketplace. Innovative new industries are being ceded to foreign firms that have the capital, skilled workforce, and motivation necessary to commercialize U.S. innovations.

Few dispute the link between education and R&D on the one hand, and the nation's competitiveness on the other. Various coalitions, councils, associations, universities and government bodies have stressed the crucial nature of the connection, as have President Reagan's 1985 Commission on Industrial Competitiveness and his 1987 State of the Union address.

To more closely explore this linkage, The Conference Board, in association with the National Governors' Association and with support from the National Science Foundation, conducted a study assessing the health of the nation's research and development enterprise and examining ways of strengthening U.S. competitiveness by improving its research and development capacity.

The Conference Board was pleased to provide a forum in which the participants from business, university and government could exchange personal experience and judgment on these critical issues. We are grateful to all those who contributed to this study by offering the insights of their company, university or state government office experience.

JAMES T. MILLS
President

Study Methodology

During the winter and spring of 1987, Conference Board researchers polled 2,300 senior research and development officers of technology-intensive companies, 500 university leaders, and senior state government officials in 50 states. Over 500 replies were received. Of the 2,300 companies polled 1,600 were selected from among the largest industrial and service-related companies (see note). These firms produce products in the following categories:

aerospace
advanced materials
agricultural
automation
biotechnology
chemicals
computer software
computer hardware
construction
defense/military
electrical
electronics
energy
engineering
medical equipment
mining
pharmaceuticals
photonics/optics
telecommunications
test & measurement equipment
transportation
utilities
waste & pollution control

The state and government respondents include the leading science policymakers in each of the 50 states. The science policy function may be housed in the governor's office, in an economic development agency, or in a special agency set up to administer science and technology programs. In addition, regional meetings were held in Holmdel, New Jersey; Seattle, Washington; and Dearborn, Michigan. The survey and the meetings solicited views of policymakers from state government, industry and academia on R&D, technology, and state research and technology initiatives. The study was designed to provide new insights and an understanding of how the roles of state and federal governments, industries and universities might need to change in order to respond to current and anticipated economic challenges.

Note: In an attempt to gather information from smaller firms, 700 firms were selected from six states: Arkansas, Utah, Washington, Michigan, North Carolina and New Jersey. The companies selected had minimum sales of $3 million per year. However, this yielded usable responses for only one question on state assistance programs (see page 23).

Highlights

This study was designed to achieve several goals: (1) to determine the importance of research and education to the economic competitiveness of the United States; (2) to identify which of the following factors have the greatest impact on U.S. competitiveness—human resources, research and development investments, technology transfer, or federal fiscal, monetary, regulatory and trade policy; and (3) to canvass the research community to determine what changes are needed to strengthen and improve the nation's research and education system. The study also sought to compare the perceptions of three different communities—the business sector, the academic community, and the state governments—on research and education policies, and to identify how the roles of each community are changing. (See box on Methodology.)

Questionnaire responses and comments expressed by participants at a series of regional conferences yielded the following observations:

- *Education was viewed by all three groups—business, academia, and government—as the key to the nation's competitiveness*. While there was concern regarding the quality of science, engineering and mathematics education at all levels, the greatest concern is for the kindergarten through 12th grade (K-12) level.
- *At the university level, attention focused on the need for state-of-the-art facilities and equipment*. Both business and state officials agreed with university officials that investment is sorely needed in laboratory instruments and buildings. There was more concern with the quality of undergraduate students than with the quality of undergraduate instruction. But there were also misgivings about the ability of colleges and universities to continue to attract and retain qualified faculty.
- *Business executives emphasized the need for high-level technical training, continuing education, and job training*. Workers can no longer expect to graduate from school with a skill that will last a lifetime; it is increasingly important to maintain a technically up-to-date, flexible workforce. University officials support this view, but opinion is divided as to which institutions should be responsible for such education and training. Some university presidents believe their institutions should provide lifelong educational tools and that retraining should occur elsewhere—perhaps at the community colleges.
- *The concept of industry/university research partnerships and state efforts to promote such partnerships generally received high marks*. But the study participants outlined a number of difficulties with implementation. Both business and university officials emphasized the need for greater corporate involvement. Industry, they argued, is not committing its "best and brightest" scientists and engineers to these joint ventures. Some university officials also expressed reservations about pressures for short-term results placed on these new partnerships.
- *Industry/university partnerships are viewed as experimental* and their outcomes and effectiveness are yet to be assessed.
- Despite general support for industry/university partnerships, *slightly more than half of the business respondents do not believe that cooperative research among industries and universities will have a critical impact on U.S. competitiveness*. Even fewer, approximately one-quarter, believe it will have a critical impact on the competitiveness of their firm. *Over 80 percent of state officials and two-thirds of the university respondents, however, believe that such research will have a critical impact on U.S. competitiveness.*
- Is the nation's current defense build up draining scientists and engineers from the non-defense sector? Will this drain have an impact on the nation's competitiveness? A majority of the conference attendees who expressed themselves on this topic think this trend is having a significantly negative impact on America's ability to remain competitive in the civilian sector. Approximately two-thirds of the survey respondents, however, do not believe that the concentration of R&D resources in the defense sector is the critical issue affecting U.S. competitiveness. *All three groups—business, academia, and government—indicated a need for increased support for non-defense basic research*.
- *Business does not see technology transfer as a critical issue affecting competitiveness. The survey responses, however, show that the term "technology transfer" is broadly used and that there is concern about issues such as the excessive time lag in the commercialization of new technology*. Several meeting participants argued that the United States has not had a major problem with commercialization—

bringing a product to market—but it has had problems involving production and marketing, that is, being able to produce a high-quality product at a competitive price.

• *Respondents from all three groups believe that business' lack of long-term goals and vision has hindered the commercialization of U.S. technology*. The business community was faulted by its own representatives for lack of patience, and the financial sector for focusing on the next quarter's profits rather than on the potential payoff from long-term investments in product development.

• With regard to state-based assistance programs, *business and university officials indicated a greater awareness and use of programs that support R&D than of those designed to assist commercialization*. This probably reflects the fact that the majority of business respondents represent large firms that have access to in-house technical expertise. Smaller companies show a greater degree of interest in the state commercialization-assistance programs.

• *Regulation is not regarded as significantly influencing U.S. success in the international marketplace*, concluded all three groups surveyed. Some particpants did say, however, that the U.S. tort liability system, coupled with the American propensity to litigate, reduces U.S. international competitiveness.

• Regarding trade policies and practices, business executives agreed with university officers and state officials that *removing protectionist measures enacted by other countries would improve U.S. competitiveness*.

• More than half of the businesses queried believe the *federal budget deficit leads the list of fiscal or monetary issues restricting the nation's ability to compete with European or Asian companies*. Their views are echoed by university and state executives, three-quarters of whom view the federal budget deficit as directly affecting competitiveness. State government officials consistently rank this area as the most important fiscal or monetary policy issue.

Introduction

The term "competitiveness" is currently used (or misused) as a semantic umbrella to cover a dizzying array of issues.[1] Some have said competitiveness is not just a buzzword of the mid-1980s, but also a "fuzzword" denoting whatever the user wants the term to mean. This study uses the definition arrived at by the President's Commission on Industrial Competitiveness in 1985:

> [Competitiveness is] the degree to which a nation, under free and fair market conditions, produces goods and services that meet the test of international markets while simultaneously maintaining and expanding the real incomes of its citizens.

In this context, success in a competitive environment is not measured solely by trade figures, sales, or market shares, but also by the standard of living of the nation's workers.

Although the United States posted strong economic gains from 1946 to the early 1970s, real wages and income from the early 1970s onward have declined.[2] Small advances occurred in the early 1980s, but more people are now working to produce the same per family income. The labor force has grown by 20 percent since 1973 and two-thirds of the new workers are women, accounting for 44 percent of all employees. Median family income, in real terms, has fallen about 5 percent since 1973.[3] A 1986 report prepared by the Joint Economic Committee of Congress concluded that if only one parent worked in an average two-parent family of the 1980s, annual family income would decline, after adjustment for inflation, by one-fourth.

Productivity—how efficiently the nation uses its labor, natural resources, and capital to produce domestic goods and services—is one of the key indicators used to measure change in the standard of living. Productivity, after having surged forward in the first two decades after World War II, has now slowed in most countries. More importantly, differences in the level of productivity have narrowed among industrial nations (see Figure 1). In the United States, productivity has increased in many sectors but, some observers point out, often with unwelcome side effects such as plant closings and wage reductions that retard advances in living standards. For example, manufacturing productivity has risen at an average annual rate of 3.5 percent since 1981, but the side effect has been lost jobs. The Joint Economic Committee concluded that while nine million new jobs were created in the United States from 1979 to 1985, many were in lower paying service occupations: 44 percent pay $7,000 a year or less.

At present, the mature economies of the world are battling for one another's markets, while keeping a wary and watchful eye on the developing countries of the Pacific Rim: Taiwan and South Korea. Countries such as Japan and West Germany have been able to stimulate their economies through national savings; they are, by comparison with the United States, nations of savers. The United States, leaning heavily on foreign savings and investment, has become the world's largest debtor nation, a condition, some say, that led to the October 1987 gyrations in the financial markets. The seemingly intractable federal budget deficit and the stubborn trade deficit have increased pressure for legislation that would retaliate against foreign countries that close their markets to U.S. goods. The U.S. trade balance is further exacerbated by the Third World debt crisis, particularly in Latin America, and the increase in the value of the dollar between 1980 and 1985.

Numerous reports from business-research organizations, beginning with the Business-Higher Education Forum's 1983 report "America's Competitive Challenge: The Need for a National Response," have proposed changes in the broad areas of technology, innovation, capital investment, education, regulatory reform, and international trade. Businesses have responded to the competitive challenge by cutting costs, downsizing, and merging with more economically efficient businesses. These are necessary first steps, but many observers point out that the next step—building new products and regaining lost markets—will be much more difficult to achieve.

Not all initiatives are at the national policy level. This report focuses on the role of the states in part because competitiveness is more than just a federal concern. The nation's governors are increasing commitments to promote economic development through support for research and technology programs. State governments have the potential to encourage

[1] Between 1983 and 1987 the term *competitiveness* appeared over 5,700 times in the titles of newspaper and magazine articles.

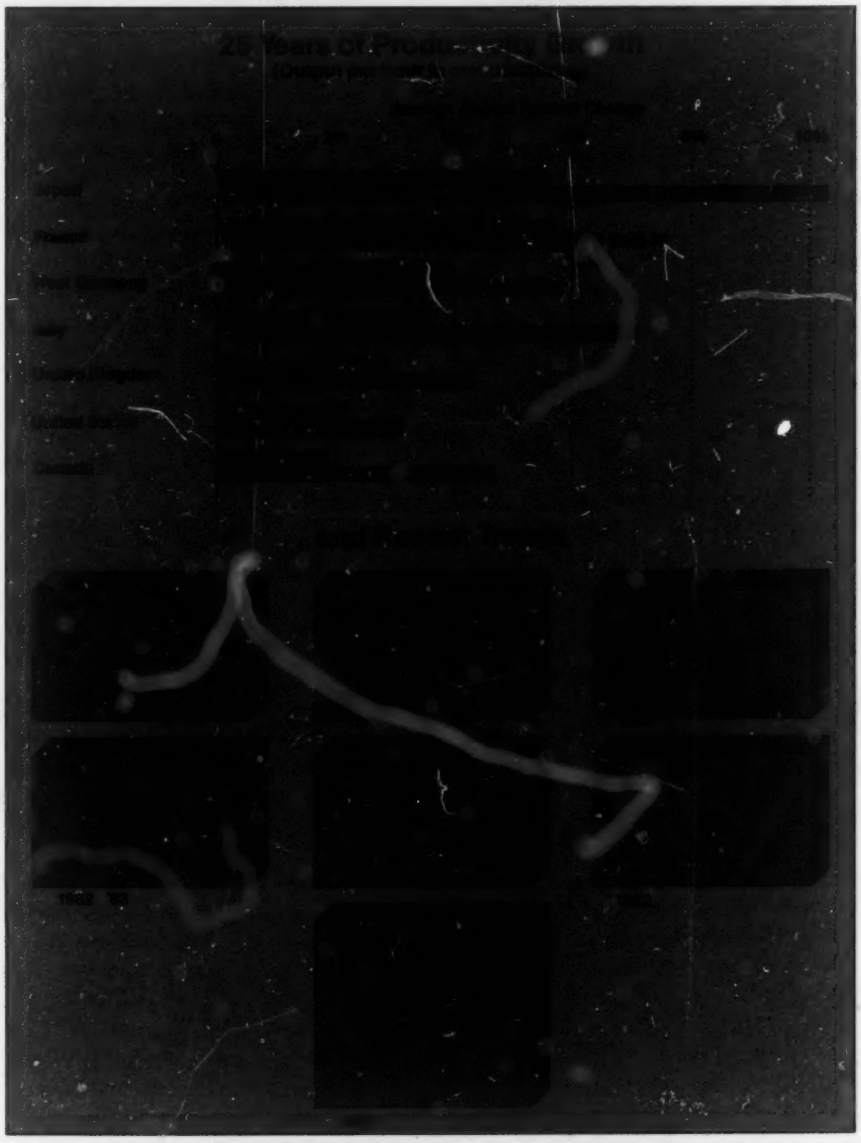
[2] Source: Department of Labor, Bureau of Labor Statistics.

[3] *Family Incomes in Trouble*, Economic Policy Institute, October 1986.

and facilitate the process of technological innovation; they directly influence the quality of elementary and secondary education as well as the employment and training essential to the development of human resources in scientific and technological disciplines. They also help support the vast majority of the nation's public institutions of higher education where much of university-based research and development takes place.

In many cases state governments also provide a critical link to the private sector, acting as catalysts to encourage the application of research findings. Over the past five years, state governments have increased funding for research and development projects, improved research facilities at state colleges and universities, and implemented a host of programs designed to help inventors and entrepreneurs start new businesses. They have also helped existing firms adopt new technological processes, and generally improved the link between the performers of research and the users.

Figure 1



Source: *Economic Road Maps*, Nos. 2009-2010. The Conference Board, April 1987.

Chapter 1

Marshalling Human Resources

Any discussion of competitiveness quickly raises the issue of America's human resources. A landmark study of one component of these resources—education—concludes:

> "History is not kind to idlers. . . we live among determined, well-educated and strongly motivated competitors. . . . America's position in the world may once have been reasonably secure with only a few exceptionally well-trained men and women. It is no longer."[1]

Traditionally, a primary competitive strength of the United States has been its human resources. The quality of its scientific and engineering professions, coupled with a highly skilled work force, has played a critical role in fostering U.S. technological innovation. At present, however, disturbing trends are evident. For example, the National Science Foundation reports that:

- Twenty years ago the United States had far more scientists and engineers per capita than any of its major trading partners. Today that is no longer the case.
- The numbers of students available to pursue science careers will decline from now until the 1990s.[2]

Concern has arisen about the quality of science and technical education at the elementary, secondary, and college level. A recent report by the National Academy of Sciences[3] found grave deficiencies in undergraduate science, mathematics and engineering education, including the following:

- Serious deterioration in laboratory instruction;
- The inability of faculty members to update their disciplinary knowledge and make use of computers and other advanced technologies;
- Courses and curricula that are outdated, unimaginative, poorly organized for students with different interests, and fail to reflect recent educational advances.
- In an international study of 19 academic test groups, American students ranked seventh, falling below the performance of students representing the U.S.'s major competitors. In no test categories did U.S. students rank first or second.
- The percentage of patents granted to U.S. citizens has declined steadily throughout the 1980s. Each year more and more patents are awarded to foreigners, especially the Japanese (see Figures 2 and 3).

Figure 2

Source: *Economic Road Maps*, Nos. 2007-2008. The Conference Board, October 1986.

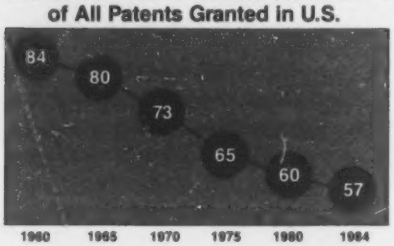
[1] *A Nation at Risk*, The Report of the National Commission on Excellence in Education, April 1983, p. 6.

[2] *Human Talent for Competitiveness*, National Science Foundation, NSF 87-24.

[3] Two recent reports, the White House Policy Council (Bromley-Packard) report on the health of U.S. universities and a report published by the Government/University/Industry Research Roundtable of the National Academy of Sciences, find widespread agreement on the need to modernize deteriorating and obsolete research facilities at universities and colleges. The latter report estimates that unmet demand for new facilities construction and renovation of research facilities will range from $5 to $20 billion in the next 10 to 20 years.

Figure 3

Patents Granted to U.S. Nationals as % of All Patents Granted in U.S.



Source: *Economic Road Maps*, Nos. 2007-2008. The Conference Board, October 1986.

Ranking Eight Factors

Eight separate categories of issues were identified within the area of America's human and educational resources. Survey respondents were asked to indicate how critical each issue is to the competitiveness of their own institution (Table 1), and then to the U.S. economy (Table 2). On the whole, the rankings are similar, but they naturally reflect the interests and experiences of the group being surveyed. University officials, for example, rate the supply and quality of science teachers slightly higher than do their industry counterparts.

The most significant variation occurs in the costs and benefits of science and engineering education. Business respondents regarded the relative earning potential for science versus law or business degree holders as more significant than did their university or state colleagues.

Approximately 10 percent of all U.S. engineering and science faculty positions are vacant. And from the perspective of all those surveyed, it is vital that the United States develop and maintain an adequate supply of science, engineering and technical personnel (Table 2). Nine out of ten business executives questioned rank this as critically important. Eight out of ten business respondents believe that fostering an adequate supply of science teachers, at all levels, and providing elementary and secondary students with a good science and math background, is indispensable to the economic future of the United States. All three audiences surveyed stressed the necessity of building an effective "science and technology infrastructure" by significantly improving

Table 1: Human Resources Issues
Percentage of Respondents Rating Issue as Critical to the Competitiveness of their Business, University, or State

Issue	*Business*	*University*	*State*
Developing and maintaining adequate supply of science, engineering and technical personnel.	77%	58%	77%
Preparation of elementary and secondary students in science and mathematics.	58	68	79
Supply and quality of science teachers at all levels.	56	68	74
Preparation of undergraduate students in science and engineering curriculum.	58	53	49
Developing public understanding of science and engineering.	22	30	30
Availability and value of continuing education programs.	24	29	51
Increased reliance of U.S. industry on foreign student graduates of U.S. universities.	15	20	19
Cost/benefits of obtaining a science or engineering education vs. other graduate training.	24	18	17

Table 2: Human Resources Issues
Percentage of Respondents Rating Issue as Critical to the Competitiveness of U.S. Economy

Issue	*Business*	*University*	*State*
Developing and maintaining adequate supply of science, engineering and technical personnel.	90%	97%	86%
Preparation of elementary and secondary students in science and mathematics.	81	86	77
Supply and quality of science teachers at all levels.	80	84	64
Preparation of undergraduate students in science and engineering curriculum.	63	71	50
Developing public understanding of science and engineering.	39	43	33
Availability and value of continuing education programs.	32	33	33
Increased reliance of U.S. industry on foreign student graduates of U.S. universities.	32	41	32
Cost/benefit of obtaining a science or engineering education vs. other graduate training.	26	25	15

science education in the K-12 grade levels. As expected, over one-half of the businesses and universities surveyed are interested in improving the supply and quality of undergraduate science and engineering students.

But there were some issues that businesses did *not* feel had a critical impact on their ability to stay competitive. For example, they were not very interested in developing a public understanding of science through continuing education programs, or concerned with the problems posed by the large number of foreign students in U.S. graduate science and engineering programs. They were slightly more concerned—by roughly 10 percentage points—with the overall impact those issues would have on the economy.

In the discussions at the regional meetings, there was also widespread agreement on the need for increased attention to the quality of K-12 education in general and, in particular, of science and mathematics education at these levels. In fact, some said particular emphasis should be paid to the K-3 grade levels.

Illiteracy is widespread among adults in the United States, survey participants note, with an estimated 23 million described as functionally illiterate. Illiteracy among minority students is reported to be as high as 40 percent. Those questioned also cite widespread shortfalls in mathematical skills. Between 1975 and 1980, remedial math courses increased by 72 percent in four-year colleges and now constitute one-quarter of the math courses taught in these colleges. Meanwhile, participants say, mathematics achievement levels have steadily fallen among high school seniors.

There must be continued investment in our university systems, meeting participants stressed, noting that federal support for university facilities and equipment has declined by 95 percent over the past 20 years. The meeting participants, in contrast to those completing the mail survey, also identified a need for retraining and continuing education.

There was little difference in opinion among the business, university and government sectors with regard to the significance of K-12 education, federal support for universities, or continuing education.

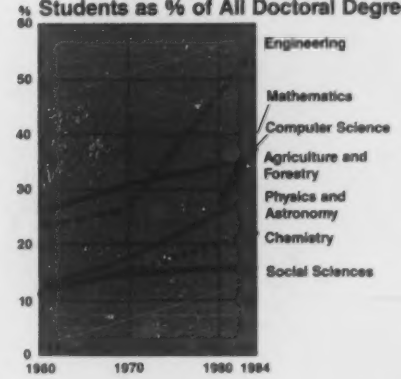
Closing the Personnel Gap

Most of those surveyed and those attending the meetings believe that the United States will soon suffer from a chronic shortage of qualified engineers, scientists, and technicians. At present, more than half of all those receiving doctoral degrees in engineering at U.S. universities are foreign students (a majority of whom are expected to return home). This is up from 26 percent in 1970. The percentage is similarly high among graduate science students (see Figure 4).

The issue of technical manpower supply was the human resources concern rated most important by the survey respondents. In general, respondents from both the business and university communities believe that market forces—particularly higher salaries for scientists, engineers and technicians—will eventually help solve the shortage issue. But

Figure 4

Doctoral Degrees Awarded in U.S. to Foreign Students as % of All Doctoral Degrees



Source: *Economic Road Maps*, Nos. 2007-2008. The Conference Board, October 1986.

over the short term the study participants believe that special incentives and improvements in education may be needed to ensure an adequate supply of skilled workers. Specific recommendations include:

- Promoting the economic advantage of science and engineering education by advertising the availability of technical jobs in the private sector;
- Expanding financial assistance to undergraduate students majoring in science and engineering;
- Subsidizing Ph.D. candidates in science and engineering who agree to teach for a two- to three-year period after graduation;
- Improving the quality and availability of science teachers in the K-12 grades by increasing salary levels;
- Providing special scholarships for science teachers-in-training.

Most of the suggestions received deal with improvements in the education system and are discussed in greater detail below.

Improving K-12 Education

The senior vice president of a multinational communications firm outlined some of the factors that have caused concern regarding the education system:

> "It is well known that 25 percent of our American students will not even graduate from high school and, of those who do graduate, many will lack fundamental reading, writing and mathematics skills. Add to this the fact that the National Science Teachers Association reports that 50 percent of all science and mathematics instructors are probably not qualified to teach. Meanwhile businesses need entry-level employees not just with a firm grasp of the basics but with high-order technical, analytical and problem-solving skills."

In addition to the general need to improve the nation's K-12 education system, a number of specific issues also surfaced. First was the need for scientific literacy, that is, a general understanding of the role and contribution of science. The meeting participants agreed that the majority of Americans will need to be science-literate to function in society. This contrasts with only 39 percent, 43 percent, and 33 percent of the industry, university, and state survey respondents, respectively, who thought that public understanding of science and engineering was critical to U.S. competitiveness (Table 2).

Second, to attract young people to science and engineering careers, the study participants believe that the United States must develop this interest at very early grade levels. Demographic changes over the next ten years indicate that, to produce a sufficient supply of scientists and engineers, the United States will have to either greatly increase the proportion of students entering such disciplines, or attract previously untapped sources, namely minorities and women. One way of responding to these problems is to focus on students at the K-3 level.

The program administrator for curriculum in one western state says:

> "We're trying to start in kindergarten, because high school is way, way too late. . . . By then, the attitudes are formed, directions are pretty well ascertained, and it's too late to have much impact on the kids if they haven't already got some kind of a bent toward science, technology and scientific literacy."

The participants believe that the recruitment of minority students should start as early as possible. A lack of role models was identified as one obstacle. In the state of Washington, for example, a state official reported, "There is no black or hispanic in a teacher preparation program for mathematics and science coming out of the pipeline (state teachers' colleges) within the next four years."

Supporting the University System

Regarding undergraduate education, the study participants identified three primary needs. First, is the need to attract qualified faculty; second, is to ensure that graduates have the skills required by business; and third, is to invest more in facilities and equipment.

Colleges and universities are faced with the problem of recruiting qualified faculty at salaries competitive with the private sector. This will become increasingly critical as faculties age and as the supply of new faculty decreases.

With regard to today's college graduates, the senior vice president for one of the largest banks in the United States reports that her division (data processing) does no entry-level hiring for recent college graduates. "The reason is that they are not skilled in anything that we can use right away," she explains. Many secondary schools are building Electronic Data Processing (EDP) systems technology into their curriculum and, while this is encouraging, the same executive says, "It may not be enough." She recommends focusing on the university system to ensure that it not only turns out quality students, but that they possess marketable skills.

Investment in infrastructure is also needed. The academic dean at one western college reported, "We haven't, with the exception of computers, replaced a single major piece of equipment since the college was completed over ten years ago." And the president of a major engineering school agreed, saying that the primary concern of public research universities in his state is the need for investment in facilities and equipment.

Offering Continuing Education and Retraining

Three-quarters of the U.S. workforce in the year 2000 are already at work. In the past, workers entered the labor force with skills useful for most of their lives. While the importance of such basic education remains, the skills required for lifelong employment are changing too rapidly—continuing education is essential. Consider, for example, that the half-life of a software engineer, that is, the time during which the essential knowledge gained from previous education will become obsolete, is estimated to be two and one-half years; that of an electrical engineer, five years.

Meeting participants recognize that demographic and technological factors require a fundamental shift in the way the United States thinks about careers and training. Investment in human resources, which traditionally focuses on training new entrants to the workforce, will have to refocus on continuing education and retraining.

Twenty-six state governments report skills-retraining programs for production, technical or research staff. About 45 percent of both the industry and university respondents are aware of these programs, but only 23 percent of the businesses and 27 percent of the universities have used them. The discrepancy between the greater importance placed on skills retraining by meeting participants, as opposed to survey respondents may reflect the fact that survey respondents considered "ongoing education" as earning advanced university degrees rather than as skills retraining.

Meeting participants also identified several obstacles to continuing education programs. They suggested that vocational and technical schools lack the resources needed to respond to changing skills requirements. National tax policies create disincentives for employees who seek educational and occupational mobility through self-initiated training efforts. There also appears to be little real incentive for employers to provide retraining activities not directly related to a specific, current need. It was argued further that, in general, the unemployment insurance system contains few incentives for displaced workers to seek retraining.

The meeting participants concluded that it is necessary to redefine the roles of industry and academia in retraining. One executive suggested that some institutions that have traditionally considered themselves "providers of broad, basic education" need to rethink their roles for the next decade.

In highly specialized technical fields, a worker trained for only one career is programmed for obsolescence.

There was a strong reminder, however, that a university education traditionally lasts a lifetime; and that job training is very different. Community colleges were seen by some respondents as the appropriate facility for retraining programs.

Government's Role

State governments have the primary responsibility for funding K-12 education and they will play a critical role in meeting future human resources needs. At the regional meetings, both Governor Booth Gardner of Washington and Governor Thomas Kean of New Jersey emphasized the fundamental role that governments play as educators.

> "The basic service we provide (among many others, but the primary service in terms of where our money goes and what I think is most important) is education. That is the foundation. We can do everything else we want in all other areas—in agriculture, trade and economic development, and a number of other areas—but if we don't have a solid foundation, all our other work is for naught."
>
> —Governor Booth Gardner

State Education Initiatives

Governor Kean referred to the leadership role of the states in the national educational reform movement: "I'm talking about higher standards for children. I'm talking about higher standards for teachers, and we are pushing at every level." Many of these state education reforms are already addressing the issues raised by the meeting participants and by the survey respondents regarding needed changes at the K-12 level.[4] But critics contend that many of the funds being spent for educational "reform" are being misspent.[5]

The issue of differential salaries for math and science teachers and changes in certification requirements were discussed by meeting participants in Washington. One state official pointed out that, traditionally, teachers within the K-12 system strongly oppose differential pay scales. He added that in his state educational officials are trying to find other incentives, such as staff development, special equipment, and additional privileges. One way in which the quality of science and mathematics education can be improved, he suggested, is to provide money for high school science labs. It was claimed, however, that in spite of problems, differential pay might soon be implemented. "I wouldn't be surprised if the resistance to pay scales in the professional education community is not overwhelmed by political and societal concern in the foreseeable future," said one meeting panelist.

Two suggestions were made with regard to teacher certification. First, to increase the number of science courses required for certification as a science teacher; and second, to ease certification requirements for engineers, physicists and mathematicians who wish to teach in the K-12 grades (perhaps by completing a one-year graduate teaching program as opposed to a traditional two- to three-year education course).

Several states, as noted, are already addressing the issues raised by the meeting participants regarding K-12 education. There are a number of possible actions that state governments might implement:

- Helping local districts enhance math and science curricula in K-12 systems by improving the quality and quantity of teachers, including the use of scholarships, grants, loans, and alternative certificate paths for teachers;
- Providing more specialized school settings that emphasize math and science, including summer institutes for promising students;
- Promoting the accelerated movement of students between secondary and post-secondary institutions for advanced learning; and
- Generating more scholarships for students going into engineering, especially into manufacturing and the sciences, by leveraging resources from the private sector.

State governments also have a role to play in retraining and continuing education, although it may be subordinate to that of the business and university communities. States can, however, use their community college systems and vocational and technical schools to provide the education needed to maintain a highly flexible workforce.

Finally, the states have a responsibility to develop programs to encourage minorities and women to enter a science and mathematics programs. As Governor Kean pointed out, "An increasing number of the children we are trying to educate are black or hispanic. It is estimated that one out of three children in our public schools will be minority children by the year 2000. We simply have to do a better job of bringing these school children and these citizens into the mainstream of American life." In the state of Washington, a program called Even Start addresses this need. It works with parents so that they will become literate enough to understand what their children are learning in grades K-3, underscoring the recommendation of the meeting participants that the best way to interest young people in mathematics and science is to begin at the K-3 level.

[4]States have raised standards, expanded the number of mathematics and science courses required of students, increased the amount of time devoted to mathematics and science, established more rigorous graduation requirements, and inserted computer literacy into the curriculum. In addition, some states have established special science and mathematics high schools, provided scholarships for students to encourage pursuit of math and science undergraduate degrees, and instituted recruitment programs for science and math teachers. (Source: *Research and Education in Economic Competitiveness: New Roles for Government, Industry and Universities*, a Discussion Paper of the Center for Policy Research and Analysis, National Governors' Association, April 1987.)

[5]"More Money Isn't Buying Better Schools," by Lawrence A. Uzzell, *The Wall Street Journal*, November 3, 1987, page 34.

Federal Support for Science and Mathematics Education

Although the major responsibility for education rests with the states, survey respondents emphasized the need for increased federal support at the K-12 levels. Meeting participants support ongoing federal activities designed to improve the quality of science, mathematics, and engineering education.[6]

An additional proposal made at the Michigan meeting was for the National Science Foundation to fund summer positions for faculty in industrial laboratories. Such internships would help to improve the skills of both secondary- and college-level teachers.

The Role of Business

In the past 30 years, corporate support of colleges and universities has risen from about $40 million to more than $1 billion. In addition to the direct support of colleges and universities, corporations currently provide an estimated $350 million in scholarships and fellowships to students, grants to pre-college institutions, donations of equipment, and support of many educational activities and organizations.

The business executives participating in the meetings believe that the business community should be more active in supporting K-12 education and should increase its participation in university-based programs. One executive used the example of a math and science center established with industry support:

> "Last year, our company gave $2 million to form and endow a math and science center. This is a brand new center containing the latest in technology for the education of high school students. In addition to providing accelerated, high-quality education for 300 students on a continuing basis, it has an outreach function that will increase and improve the quality of science education and awareness in the entire community. I think that this kind of modest investment will do more toward improving this country's technological competitiveness than anything else we could have done with the money, including the worthwhile endowment of one or more university chairs."

The meeting participants agreed that corporations should play a major role in meeting retraining and continuing education needs in the United States. They pointed to the fact that most large corporations have broad employee education programs that include tuition refunds, time off for advanced degrees, and substantial internal education programs. A participant noted, however, that it is important to distinguish between small firms, which have neither the scale nor the resources to provide ongoing employee training and large corporations, which are able to offer such training.

Corporations also have specific ideas on how they can assist university-level education, and these agree strikingly with the views expressed by their university colleagues. The primary ways, rank ordered, are:

- By participating in student cooperative programs;
- By providing staff members to serve as adjunct faculty;
- By donating funds and equipment to university laboratories.

Several firms in Washington and Oregon suggested that business could assist in curriculum development. "We are applications-oriented. We can help university engineering departments stay in a practical venue by participating in curriculum planning and by providing insight into industry's technology needs." A midwestern company executive wrote, "We would like to assist in teaching and provide hands-on experience with our advanced equipment."

Several firms in Minnesota, Michigan, Montana and Illinois recommended expanding student internships, visiting-professor programs, industry-supplied part-time teachers, and two-way sabbaticals. An Illinois manager writes, "We can help by establishing strong, informal communications channels between universities and our R&D laboratory. This can be accomplished by joint research programs, joint seminars, informal visits, and grants to faculty in important, emerging technology areas."

[6]The National Science Foundation's fiscal 1988 budget included several initiatives to improve science and engineering education at pre-college, college and graduate levels. Pre-college activities, which include hands-on research experience to encourage science, mathematic and engineering careers through enrichment activities for talented high school students and development of improved teaching materials, are funded at $90 million under the new budget. An additional $70 million will be used to improve the quality of undergraduate instruction. New activities include:

- Instrumentation and laboratory instruction;
- Student research participation;
- Faculty enhancement; and
- Curriculum development in calculus and engineering.

The Department of Education also provides support for improving science and mathematics education. Funded at $80 million for fiscal 1987, this program provides grants to states to offset part of the cost for training and retraining mathematics and science teachers at the secondary level.

Federal agencies, for the most part, support graduate and post-doctoral level education through research project support and competitive fellowships. In 1985, NSF, the National Institutes of Health, the Department of Defense, and other federal agencies, supported 20 percent of all full-time engineering and science graduate students in doctorate-granting institutions.

NSF also operates programs designed to encourage promising young scientists and engineers to remain in academic careers (such as the Presidential Young Investigator's Award Program) and to encourage women and minority students to pursue science and engineering careers.

Chapter 2

Investing in Research and Development

Meeting Research and Development Needs

Investment in R&D is often credited with making the United States the world leader in science and technology and with related growth in economic productivity. U.S. spending on research and development in 1987 is estimated at $125.2 billion. Roughly half of these funds are provided by the private sector, with the federal government providing most of the remaining half, and states and other sources providing 3 percent of the total.[1]

There is concern, however, that the United States is losing its technological dominance. First, while U.S. investment in R&D is the highest of any country in the world, investment in non-defense R&D, as a percentage of GNP, is less than that of Germany and Japan. In 1983, the United States invested 1.91 percent of its GNP in non-defense R&D, while Germany invested 2.47 percent, and Japan 2.60 percent.[2] The federal investment in applied research and in development in non-defense areas is estimated to have declined by 17 percent and 55 percent, respectively, in constant dollar terms between 1980 and 1985. Business support of applied research over the same period grew at an average annual rate of 10.2 percent in constant dollars, but this far from makes up the deficit in civilian R&D support by the federal government.

Second, the portion of the workforce engaged in research and development in competitor countries has increased sharply since 1965 and is beginning to approach current U.S. levels; Japan and Germany, for example, have doubled their R&D workforces. These factors raise concern regarding the ability of the United States to maintain its leadership.

The Conference Board survey examined how U.S. research and development resources are allocated and attempted to gauge the impact on U.S. competitiveness of prospective increased support for university and cooperative research. Researchers identified five primary issues and asked business, state and university officials what strategic impact these issues would likely have on their institutions and on the economy as a whole. Table 3 identifies these issues and indicates the critical impact that respondents believe they have on their institutions' competitiveness. Table 4 shows the impact these factors are believed to have on the economy as a whole.

Clearly, all of the groups questioned believe that the United States must increase its output of state-of-the-art R&D equipment and boost industry's access to such equipment in order to maintain its competitiveness and, even more significantly, to gain on its competitors. Linked to this factor is the issue of increased support for civilian research and for efforts to increase joint, intra-industry R&D as well as cooperative ventures between industry and universities.

University and state officials rate increased support for

Table 3: R&D Issues
Percentage of Respondents Rating Issue as Critical to the Competitiveness of their Business, University, or State

Issue	*Business*	*University*	*State*
Access to state-of-the-art R&D equipment and facilities			
A. by industry.	52%	46%	65%
B. by university.	38	71	83
Increased support for civilian basic research as performed			
A. by industry.	25	26	49
B. by universities.	28	64	65
Importance of cooperative research			
A. among industries.	26	20	35
B. among industries and universities.	27	52	74
Significance for increasing industry support for university-based research.	20	52	54
Concentration of research and development resources in the defense sector.	10	10	35

[1] *Science and Technology Data Book*, National Science Foundation, 1987, p. 4.

[2] Ibid., p. 38.

Table 4: R&D Issues
Percentage of Respondents Rating Issue as Critical to the Competitiveness of the U.S. Economy

Issue	*Business*	*University*	*State*
Access to state-of-the-art R&D equipment and facilities			
A. by industry.	69%	81%	68%
B. by universities.	66	78	78
Increased support for civilian basic research as performed			
A. by industry.	46	57	50
B. by universities.	57	72	67
Importance of cooperative research			
A. among industries.	44	44	45
B. among industries and universities.	45	67	83
Significance for increasing industry support for university-based research.	34	59	62
Concentration of research and development resources in the defense sector.	34	35	48

civilian basic research, and substantial increases in industry support for university-based research, significantly higher than do corporate R&D executives. Particularly revealing is the respondents' assessment of the variance between the micro and macro impacts. This is most noticeable with respect to the concentration of research resources in the defense sector. While only 10 percent of the industry and university respondents said this had any effect on their individual competitiveness, more than one-third said it had a negative impact on the nation's international competitiveness.

Access to Facilities and Equipment

Many of the business leaders surveyed believe that in order to make significant gains on its major trade competitors, U.S. industry needs more access to state-of-the-art R&D equipment. Over two-thirds of the respondents ranked this as either of critical or moderate importance (Table 4). Many university leaders agreed, citing what they describe as "the deplorable state of university research and development equipment." Several respondents commented that the equipment science and engineering students use is often older than the students themselves. University leaders would like to see more sharing of equipment with industrial laboratories and, naturally, would encourage business to make equipment donations. State government officials also placed a high priority on the need for universities to have access to state-of-the-art R&D facilities and equipment.

Increased Support for Research and Development

Many respondents believe that increased support for civilian basic research—as performed by industries and universities—is critical to the competitiveness of the U.S. economy. Fifty-seven percent of the business leaders, 67 percent of the state officials, and 72 percent of the university officials support increases for university-based civilian research; approximately 50 percent of each group favors increases for civilian basic research by industry. Over 60 percent of the state and university respondents say that increased industry support for university-based research also critically affects U.S. competitiveness. However, only a third of the business respondents share this view.

Importance of Cooperative Research

State government officials placed highest priority on cooperative research among industry and universities, with over 80 percent rating this issue as vital to U.S. competitiveness. Less than half of the business respondents and two-thirds of the university respondents agreed. In addition, less than one-third of the business respondents rated either cooperative research among industries or among industries and universities as critical to the competitiveness of their companies. This response indicates that many business leaders do not perceive a pressing need for joint industry/university ventures. This "traditional" viewpoint, according to state officials, is one of the barriers to innovation. One of the goals of many state programs, therefore, is to change this perception. Survey data suggest that attitudes must change if cooperative ventures are to play a major role in supporting R&D.

Concentration of R&D Resources in the Defense Sector

Although all three survey groups believe that greater investment in civilian R&D is a critical issue affecting U.S. competitiveness, only one-third of business and university officials regard the concentration of R&D resources in the defense sector as critical. In contrast, nearly one-half of state officials think this critically impacts the nation's competitiveness.

The issue of whether the current defense build up is draining off scientists and engineers from the civilian sector, and whether this drain is having an impact on the nation's competitiveness, engendered some debate. A majority of debaters thought that this trend was having an adverse, if unquantifiable, impact on America's ability to remain competitive in the civilian goods sector. Dissenters pointed to a recent National Academy of Engineering study, which states,

> "Job offers from defense firms have acted to offset declines in recruiting activity by the commercial sector and to absorb increases in the supply of engineering graduates."[1]

[1] *The Impact of Defense Spending on Non-Defense Engineering Labor Markets*, National Academy of Engineering, 1986.

The Changing Nature of R&D

Participants at the state meetings commented on what they saw as necessary components of the effort to rebuild R&D resources. They generally agreed that the issue is not whether the United States is spending sufficient dollars on research and development. The vice-president for R&D of an automotive company expressed it this way: "Probably what is more important is the quality of the research, the attitudes of the people that do it, and the direction in which it is aimed."

Study participants noted that research is becoming more complex, more capital-intensive, and more dependent on sophisticated instrumentation and computers. Appropriately, about 80 percent of business respondents identified access to state-of-the-art equipment and facilities of critical or moderate importance to U.S. competitiveness. Another important facet of the changing R&D picture, as noted by participants, is that research is becoming increasingly interdisciplinary. While it has always been true that new fields are created at the boundaries of existing ones, meeting participants suggested that this now happens at an accelerated pace. As the president of a major pharmaceutical company reported, "We have within our biological [research] department no less than fifteen [separate] disciplines represented."

Another change involves a recognition that the line between basic and applied research is blurring and that greater interaction is needed between basic research and technology development. One meeting participant said, "We have come to realize that the innovation process is not sequential (pure science leading to technology and then to economic opportunity), but involves strong coupling—both ways—between technology and basic science. Each is stimulated by, and dependent on, the other."

One response to the changing nature of R&D has been the proliferation of new institutional relationships between businesses—the primary users of research—and universities, where most basic research occurs.

Redefining Roles for Industry, Universities and Government

Study participants agreed that to meet the challenge of economic competitiveness, the United States must not only make a commitment to its research system but must also redefine how government, businesses and universities relate in the conduct of research and in the use of research findings. The study focused specifically on new industry/university research partnerships and sought to answer the following:

- What is the level of commitment on the part of businesses and universities to these new partnerships?
- How effective do the respondents feel these joint efforts have been?
- What obstacles have been encountered in implementing industry/university programs?
- What steps could be taken to improve such arrangements?
- What is the opinion of business and university leaders regarding state efforts to promote partnerships?

R&D Partnerships

Although business support for industry/university ventures appears mixed, over the past several years there has been a large increase in the number of new industry/university research partnerships. For universities, these partnerships offer the prospect of additional research dollars at a time when competition for federal dollars is on the rise. Universities also benefit from donations of state-of-the-art equipment and from increased opportunities for both students and faculty to interact with industrial researchers. Industry participation in these alliances is motivated by the need to develop and adopt new technological processes and products quickly and to secure access to innovative researchers and fresh ideas.

The chairman of one state's Commission on Science and Technology argued for the creation of university-based industrial research centers, saying that industrial academic partnerships centered in universities can provide industries with an arena for long-term strategic thinking removed from some of the short-term pressures of the marketplace and day-to-day political considerations. Such centers would give industry direct access to academic research excellence, as well as to faculty and students. In return, businesses would participate by enrolling in the centers, donating equipment, sponsoring research, and, most importantly, assigning key people to serve on advisory boards and conduct research.

The meeting participants shared the enthusiasm of state officials for these new partnerships. They believe that close linkages between universities and industry are critical to the nation's future competitiveness. Many cited the special synergy that takes place when market-oriented industry scientists get together with their basic research-oriented university colleagues.

While less than half of the business executives polled believe that joint industry/university research is critical to the nation's competitiveness, when asked to assess existing partnerships, the business responses were generally positive. Of responding firms, four-fifths were aware of state initiatives to promote joint industry/university research projects, and nearly two-thirds have participated in such programs. Over two-thirds of the business respondents gave these programs a high ranking. Three-quarters of the university respondents were aware of the programs, and 57 percent had participated in them. The university respondents were also supportive of the programs, with three-quarters ranking them high in terms of effectiveness. Thirty-five states reported enacting joint industry/university initiatives, thirty-two of which are currently operational.

Joint Ventures Among Competing Companies

Joint ventures among competing companies are viewed differently than industry/university partnerships. One firm volunteered that it was generally opposed to joint ventures between competing companies because "such arrangements

tend to retard the introduction of new technology to the marketplace." And a Washington-based company points out:

> "Joint R&D ventures, particularly between competing companies, are often very difficult...and potentially illegal. It might be possible for government to establish university R&D funds that could be spent investigating specific areas of interest to industry. In such scenarios industry would be involved, to a limited extent, in directing the research effort."

University R&D executives were also hesitant about such arrangements. An official at one Alabama university says: "Universities would be more effective if they shied away from joint ventures that involve two or more competing companies. Industry is better served with bilateral agreements with university research sources." And an official at one midwestern engineering college states, "Fostering cooperation among competitors can be tantamount to state-sanctioned monopolies and should not be encouraged."

On the other hand, several study participants called for further easing of antitrust restrictions to allow joint research. Although legislation has been passed allowing cooperative research, some business respondents expressed concern that such regulations would be subject to change. An Indiana-based company stated that in its experience "the mere easement of antitrust restrictions, in a generalized way, is not enough. We need specific relief from the risks we see on specific joint R&D projects. That easement should be [more] specific and should be formalized."

Impediments to Partnerships

Meeting participants emphasized that these new initiatives are challenging both universities and business to change in fundamental ways. A number of obstacles were identified that make true partnerships difficult to achieve. First, belief that industry and university researchers operate from different perspectives—what is sometimes referred to as the "two-

New Partnerships Emerge

Industry Support

The past several years have witnessed an explosion of new industry/university partnerships. Industry participation in such alliances has resulted from its need to quickly develop and adopt new technological processes and products in order to succeed in an increasingly competitive marketplace.

One of the best known examples of an industry/university joint venture is the Monsanto/Washington University program. Washington University in St. Louis and Monsanto, in an effort to expand into the biotechnology market, signed a joint research agreement in 1982 under which Monsanto would pay the university $62 million over eight and a half years. Under the program, university and industry researchers are working together to speed up the evolution of basic research findings into products for the market.

Another example of an industry-supported research effort is the Semiconductor Research Corporation, a non-profit consortium of U.S. companies. The corporation was established to strengthen generic research capability in semiconductor technology. It has 60 members and spends 90 percent of its budget on university research projects.

State Support

Government policies, particularly at the state level but also increasingly at the federal level, have encouraged these relationships. State support for R&D is a fairly recent phenomenon. In the past, state governments played a key role by providing direct support for R&D activities, predominantly through university-based technology research centers, which are sometimes referred to as centers of excellence or advanced technology centers.

University technology research centers are vehicles for conducting research in specific technological areas. Usually the state identifies those areas in which the university system has expertise or that are particularly pertinent to the state's major industries. Centers focus on these targeted areas with the state acting as a catalyst to bring together the resources of the private sector and of the university. The following are examples of state activities in this area:

The New York Advanced Technology Centers Program is designed to encourage industry/university cooperation on applied R&D projects. Seven advanced technology centers have been established at universities throughout the state. Each center focuses on a specific area of technology, including computers and information systems, agricultural biotechnology, telecommunications, health-care instruments and devices, medical biotechnology, computer applications and software engineering, and advanced optical technology. The state has provided funds for equipment, faculty and research staff. The specific appropriation to the Advanced Technology Centers Program is used to develop capabilities and provide project support. The Program is administered by the New York Science and Technology Foundation, a public corporation

culture" problem. Some participants said that the traditional attitude of many faculty members, which is also reflected in the university's incentive structure, is to explore knowledge for its own sake and to disseminate research findings through publication. In contrast, industry managers tend to be concerned primarily with products that have commercial applications and to seek protection of proprietary data.

The director of a state university research and technology park outlined the following obstacles that he believes inhibit the transfer of basic research findings to the private sector:

> "Consulting with industry is not an important criterion for promotion, merit increases, or tenure in the university system. In fact, most universities have explicit or implicit policies against it. The same is true with applied research and contract research with respect to industry. It is not encouraged and does not receive the same kind of positive evaluation that basic research does. In addition, would-be faculty entrepreneurs are discouraged from taking equity positions and participating in a start-up venture, not only because their peers look down on it, but because state laws and university policies have regulations against it."

An officer of another university commented: "Publication continues to be a problem. It is the key to success in the academic research environment, but the restrictions associated with disclosure and patenting (both nationally and internationally) are viewed as interfering with the publishing process by most researchers."

But universities are not alone in setting up barriers to meaningful participation in joint R&D activities. A number of meeting participants suggested that industry involvement in these partnerships is often more symbolic than real. A common complaint is that industry does not commit its best people. One participant in a joint R&D center elaborated: "The Japanese are sending people equal to, or better than, the top 5 percent of their graduate students. The U.S. companies are sending people looking for a year to tide them over and who don't contribute very much."

governed by an eleven-member board appointed by the governor with the advice and consent of the state senate.

The Ben Franklin Partnership Program, located in Pennsylvania, provides grants for applied R&D activities and for technical and financial assistance to entrepreneurs and existing businesses. The largest program operated by the partnership is the Challenge Grant Program, which uses matching funds to establish four Advanced Technology Centers. Each center represents a consortium of groups from the private sector, labor, research universities, and other higher education institutions, as well as economic development organizations. The centers conduct joint R&D projects, sponsor education and training activities, and provide entrepreneurial assistance services.

Federal Support

Recent federal efforts to promote greater industry/university linkages include (1) the newly established Engineering Research Centers (ERC's) program of the National Science Foundation; (2) the university initiative of the Department of Defense; and (3) the Reagan Administration's proposal to establish Science and Technology Centers throughout the country.

The purpose of the NSF's ERC program, established in 1985, is to develop fundamental knowledge in engineering fields that will enhance the international competitiveness of U.S. industry and prepare future engineers. The centers support cross-disciplinary research and promote close industry/university work relationships. Eleven centers were funded in the first two years of the program. Five new centers were proposed for FY 1986, bringing the total to sixteen. The NSF's FY 1988 budget requests $48 million, up from $30 million in FY 1987, to provide funding for five additional ERC's for a total of twenty-one.

The Reagan Administration has proposed expanding the ERC concept to Science and Technology Centers in the FY 1988 budget. These centers would be established in areas such as computer and information sciences, materials sciences, biology, and biotechnology. The FY 1988 budget includes approximately $40 million to fund five to ten centers.*

The Department of Defense has created a University Research Initiatives Program, a multicomponent effort to strengthen the capability of universities to perform research and to educate scientific and engineering personnel in disciplines important to the technologies underlying a strong national defense. The program includes the establishment of research centers focused on specific technologies.

*The recent appropriations decisions of Congress, however, will slow down this program.

Source: *Research and Education in Economic Competitiveness: New Roles for Government, Industry and Universities*, A Discussion Paper, Center for Policy Research and Analysis, National Governor's Association, April 1987.

A university official reported: "Business and industry support joint research centers, but we have to be more successful at getting corporate scientists to participate. Companies invest many millions of dollars in a center and then attend maybe two seminars. The Japanese will send 23 of their best young scientists, who take the trouble to learn our language and culture, and who give as much to the program as they take from it." An executive of a large U.S. corporation contributing to a research center also has problems with the quality of U.S. participants: "We put in our $50,000 a year and we attended two seminars. . . .The Japanese sent 22 full-time people to participate in the program for one year. We, U.S. industry, are guilty of putting money where it counts, but then not participating fully in the education process."

In addition to not participating, it was suggested that industry generally sends junior staff from their research units, not senior people responsible for product development, manufacturing, or design functions. This, especially in the case of manufacturing, causes problems in terms of moving research findings into the marketplace.

A final issue that was raised is the ability of small businesses to participate in cooperative research ventures. A midwest center director argues that "virtually all the cooperative programs that have been given a lot of publicity are targeted toward Fortune 1000 companies. Rarely do you find small companies, whether they're start-up or established companies, involved in cooperative research ventures. They don't have the capital and it is difficult for them to connect up with the universities."

Survey data upheld this contention. While 81 percent of the firms with 500 or more employees were aware of joint research programs and 71 percent had participated in joint ventures, only 54 percent of the firms with fewer than 500 employees were aware of the programs and only 35 percent had used them.

There was also concern regarding the impact of university involvement in cooperative programs. Some university officials argued that the fundamental role of the university is education. If universities are to change and assume a strong economic development role, consideration must be given as to how such efforts should be supported and how this mission fits in with the overall mandate of a university.

The dean of engineering at a major research university, which has a number of research centers, expressed concern that "the best and brightest faculty, young and old, are chasing money now. They are not chasing ideas." An official from another university disagreed. "With the research center concept, it is the director, not the researcher, who focuses on writing proposals that go to various government agencies. Now the faculty researchers have more time to think without worrying about money."

Making Partnerships Work

Survey respondents were asked to look ahead to what steps could be taken to encourage the growth of industry/university R&D ventures. Some frequently mentioned steps and strategies include the following:

- Modifying existing antitrust restrictions to encourage R&D joint ventures;
- Expanding the number of technology centers;
- Providing direct federal financial support for certain industry/university partnerships;
- Establishing multi-industry, multi-disciplinary research parks;
- Changing laws to allow faculty members to take equity positions in R&D joint ventures; and
- Developing uniform terms and contracts for joint ventures.

The meeting participants agreed that effective mechanisms for interaction are needed and proposed fundamental changes in the behavior and incentive structures of both industry and academia. The business respondents recommended that university policies regarding faculty consulting, equity positions, and conflict of interest be reviewed and that incentive programs to encourage the disclosure and patenting process be put in place.

University reactions to these suggestions are mixed. One university official argued that the limiting factor today is not unwillingness on the part of the university to allow open communication. Rather, "it is the lack of financial support in the university to prepare itself as a worthy collaborator." Another participant recommended the development of new organizations as a way to improve interaction between industry and universities. "What is needed are hybrid organizations, organizations that might be within a university or somehow related to the university."

Some university presidents reminded the regional meeting participants that much of industry's support may be too narrowly focused. That is, they said, aid to university research should have fewer "strings" attached, such as not being narrowly targeted to specific technical goals. Sometimes the restrictions on the aid they receive are so tight that the university scientists are unable to explore alternative solutions that, ultimately, might be more beneficial to industry sponsors.

There were also a number of recommendations regarding the involvement of private firms in cooperative ventures. Business must be willing to commit their "best and brightest" staff to cooperative ventures and include representatives from the various operating units of the organization (e.g., design, producton, and marketing) in research partnerships.

State Government Support for Cooperative Research

Participants also recommended that government, particularly state government, play an important role in encouraging industry/university cooperation. As described earlier, the participants reacted positively to current state efforts to support R&D. In addition to supporting joint industry/university research projects, approximately half of the business

respondents and two-thirds of the university officials gave research matching grants a high rating.

Two aspects of state initiatives were labeled particularly promising: first, that states have developed integrated strategies for pursuing economic competitiveness, and second that experimentation is occuring at the state level. With regard to the former, a university official referred to the imaginative leadership taken by his state in building a strategy for job creation. "This strategy focuses on a state-based program emphasizing an attractive business climate, education reform, and encouragement of new technological capabilities wherever they can be nourished." He added: "I think it is a tremendously important contribution state governors have made and I think this is something that federal officials need to look at very hard. The federal government has not, in my opinion, integrated its education strategy, its technology strategy, and its business encouragement strategy into nearly as coherent a program as the state of New Jersey, the state of Massachusetts, and several others." He recommends a closer relationship between federal agencies that support science and technology and the states that are building meaningful strategies.

Federal/State Cooperation

At each of the regional meetings, participants were generally supportive of the initiatives of the National Science Foundation and of other federal agencies to encourage multidisciplinary cooperative research through the Engineering Research Centers, the University/Industry Cooperative Research Centers, and the newly proposed Basic Science and Technology Centers of the National Science Foundation, as well as the Department of Defense's University Research Initiative.

The chairman of a state commission on science and technology argued, however, that the impetus for cooperative R&D must remain with the states. "We in the states are close to our people, close to our industries, and certainly close to our higher education institutions." He added that the states need help in forging R&D partnerships and asked that the federal government, particularly the National Science Foundation, work with the states to strengthen these new partnerships.

The Question of "Targeting"

The survey respondents disagreed with the meeting participants on the wisdom of state efforts to target particular industries or technologies. Both industry and university officials surveyed rejected such a strategy. Some respondents indicated that they were distrustful of the ability of either state or federal government officials to effectively implement a targeting strategy. They suspected the decision to target would be determined by politics, not economics. One respondent cautioned that "there is a lot of herd behavior and, frequently, important breakthroughs came from areas that were unpopular at a particular time."

Meeting participants largely took the position that targeting, if it were to be done at all, should occur at the state, not the federal level. Several participants favored state targeting, arguing that states have the ability to identify technological niches of importance to both their own and their regional economies. (Further discussion of targeting relative to national policy issues appears on pages 19 and 29, respectively.)

Assessing Progress to Date

Finally, a few words of caution were raised regarding the danger of excessive expectations for cooperative research ventures. The dean of engineering at one university stated: "It is going to take some time for this experiment to mature, and the expectations, particularly at the state level, are for instant success. . . . It's going to take at least a decade to know whether bright young people are coming into the field of manufacturing and technology for the civilian market, before we have a real sense of change."

Erich Bloch, director of the National Science Foundation, defines success somewhat differently, "I would define success as follows: if universities change in two ways. First of all, by developing cooperative relationships with industry and also between their own departments and disciplines. The second measure is the contribution made by science and technology and engineering centers to the educational process. And I would say if this can be achieved, then I would call this great experiment a success."

Meeting participants often raised the issue of the willingness of states to experiment. "The thing about the state governments that is exciting is that no one assumes he has the answer, and everyone is trying experiments. A lot of them are going to fail, but many of them are going to succeed," said the vice president for research of a major midwestern corporation. The meeting participants also believe that because these efforts are experimental there is need to measure their outcomes and to assess their effectiveness.

Chapter 3

Creating an Innovative Environment: Getting Ideas to the Marketplace

A strong R&D base, in and of itself, does not guarantee competitiveness. The United States needs to ensure that the knowledge and technology developed are translated into marketplace advantages. Both survey respondents and meeting participants expressed concern about the U.S. capability to move products from the laboratory to the marketplace. In fact, this is the area in which U.S. performance is viewed as weaker than that of its major competitors. For example, the videocassette recorder was invented in the United States in 1956; today not one VCR is produced in the United States and two Japanese firms, Sony and Matsushita, control 90 percent of the U.S. market. In 1986, for the first time, the United States ran a trade deficit in high technology products. (Additional comments on barriers to innovation appear in the chapter "Regional Observations," pages 25 to 32.)

Transfer of Technology

Numerous public as well as private policies and regulations affect how successful the United States is in converting ideas into commercial products. At least four primary issues under the rubric "transfer of technology" seem to be involved:

- Excess time lag in commercialization of technology;
- Lack of clarification of policy on intellectual property rights and patent reform;
- Lack of access to federally sponsored research results; and
- Foreign government prohibitions restricting transfer of technology from their territories by U.S. firms.

Their importance, according to the survey respondents, is shown in Tables 5 and 6.

Again, assessments of the impact on a particular firm or university versus the impact on the entire economy differ significantly. For example, while only 21 percent of the business respondents said that property rights and patent reform are of critical importance to their firms, 35 percent think that they are of critical significance to the U.S. economy. In addition, nearly half of the state respondents rate clarification of policy on intellectual property rights and patent reform as a critical issue affecting U.S. competitiveness. (A more detailed discussion of the technology transfer question relative to other issues appears on page 20 under "Ranking the

Table 5: Barriers Related to Technology Transfer
Percentage of Respondents Rating Issue as Critical to the Competitiveness of their Business, University, or State

Description of Barrier	*Business*	*University*	*State*
Excess time lag in commercialization of technology by			
A. industry.	37%	12%	40%
B. universities.	14	14	33
Lack of clarification of policy on intellectual property rights and patent reform.	21	15	42
Lack of access to federally sponsored research results by			
A. industry.	18	19	40
B. universities.	18	33	37
Foreign government prohibitions restricting transfer of technology from their territories by U.S. firms.	9	4	10

Table 6: Barriers Related to Technology Transfer
Percentage of Respondents Rating Issue as Critical to the Competitiveness of the U.S. Economy

Description of Barrier	*Business*	*University*	*State*
Excess time lag in commercialization of technology by			
A. industry.	52%	42%	42%
B. universities.	27	35	35
Lack of clarification of policy on intellectual property rights and patent reform.	35	26	49
Lack of access to federally sponsored research results by			
A. industry.	27	42	51
B. universities.	29	42	51
Foreign government prohibitions restricting transfer of technology from their territories by U.S. firms.	18	23	30

Issues.") There was considerable agreement among all communities surveyed that the time lag in the commercialization of new technology is an issue that puts the United States at a competitive disadvantage in world markets.

As shown, university and state officials feel much more strongly than do their business counterparts about access to federally sponsored research and the effect that this issue has on competitiveness. While less than one-third of the businesses believe that access to federally sponsored research is having a significant impact on competitiveness, 40 percent of the universities and 50 percent of the state officials believe this is adversely affecting U.S. competitiveness. Less than 10 percent of the companies and very few universities are critically affected by foreign governments' restrictions over the transfer of technology developed by U.S. subsidiaries in those countries.

Barriers to Commercialization

Respondents used the survey's open-ended questions to comment on what they saw as important barriers to commercialization. Meeting participants also contributed to this discussion. In particular, survey respondents from all three sectors faulted the business community for lack of patience, for being preoccupied with the next quarter's profits rather than the potential payoff from long-term investments in product development. Short-term responsibility to shareholders was acknowledged, as well as how this duty is met—often at the expense of product development that can occur only over the long term. At the regional meetings, a number of participants shared with the audiences personal or corporate experiences with losing markets to foreign producers—markets for products for which the United States invented the technology.

In discussing the reasons for the poor commercialization performance of U.S. industries, the respondents and meeting participants placed part of the blame on management. In some instances it appeared that corporate bureaucracy had prevented rapid commercialization of U.S. technology. Many of the state officials responding to the survey agreed, listing the following among the three most significant barriers to innovation in their states: "industrial reluctance to abandon traditional objectives for manufacturing," "lack of awareness of technological threats to their future" on the part of industry, and "attitude of private industry toward the need for long-term innovation."

On a separate issue, a number of company representatives decried the lack of intellectual property rights protection among foreign competitors and claimed that their own secrecy and unwillingness to test-market certain innovations was based on a reluctance to expose product prototypes to foreign firms.

The Concerns of Small Businesses

Some respondents said the United States should look to small business as a primary source of innovation, suggesting that small businesses are more likely to introduce new products and to adopt new technological processes. One reason is that "entrepreneurs are staking their careers, their lives, literally their livelihood to develop a technology. They have a vision."

Respondents and meeting participants from small companies pointed out some of the many barriers faced by new technology-based firms. First and foremost is lack of venture capital. Several speakers referred to the desire of venture capitalists to want their money back quickly. Some spoke of "vulture capitalists," claiming financiers demanded an unfair share of new businesses. Another panelist pointed out: "The problem with venture capitalist money is that it is very expensive. You're talking about royalties of 6, 7, 8, or 9 percent. So when you're paying a venture capitalist back, the company starts teetering."

One program reported to be particularly effective in providing seed capital for new businesses is the federal Small Business Innovation Research Program (SBIR).[1] But providing capital for new products and new businesses, while necessary, may not be enough. Many inventors or entrepreneurs require assistance in a variety of areas, from developing a business plan to managing and training a workforce.

The director of a state-supported product development fund describes his agency's experience:

> "One of the things that we have learned is that, in terms of commercialization, it is not sufficient with most companies for us to provide only the funding for product development. There are two additional functions that have to be provided. One is assistance in either obtaining or supplying the money necessary to enter the marketplace. The second is perhaps more important—and a lot harder to define—and that's 'hand-holding.' This is important for companies that are short on management skills in one area or another. We believe that if our investment is to stand the greatest chance of success, we're going to need to provide support services."

Several small business owners participating in the meetings identified their need for technical support services. In the words of one spokesperson, "We need capital equipment, part-time expertise, and the resources to train people. In any kind of a high technology business, there is no way you can do it all yourself as a small company." Another entrepreneur

[1]The Small Business Innovation Research Program (SBIR), established in 1982 by the Small Business Innovation Development Act, requires that each federal agency with an external R&D budget exceeding $100 million spend a specified percentage (up to 1.25 percent) of said budget via a special program targeted to small firms.

The SBIR program consists of three phases. Federal agencies request proposals from small businesses responsive to the agency's research and development needs. After evaluating the proposals, each agency awards Phase I grants, which provide funds for determining the technical feasibility of the R&D concept. Grantees are then eligible to apply for Phase II awards to fund full-scale R&D. The third phase, additional work to develop Phase II research results into commercial products, is expected to be funded with non-SBIR funds.

proposed: "Provide funding to bring faculty out to our companies and have them work with us. We cannot support them ourselves."

Additional suggestions were offered for improving commercialization:

- Developing more accurate indicators of technology transfer so that U.S. strategists have a better grasp of the dimensions of this problem;
- Increasing interaction between technologists at primary manufacturing firms and those in supplier firms;
- Developing a cadre of technology transfer agents or mechanisms to permit entrepreneurs to acquire and commercialize technological discoveries unused by either major laboratories or university research centers; and
- Providing specialized advice and technical support for small firms seeking to commercialize leading-edge technologies.

In summary, the meeting participants regard effective commercialization as one of the leading factors in keeping the United States competitive. They are dissatisfied with the mechanisms now available and are searching for improvements and replacements.

Chapter 4

National Policy Issues

Survey participants concentrated on human resources, education, R&D investments, and state assistance programs, but also had an opportunity to comment on and evaluate a variety of economic, regulatory and strategic policies that are often said to have an impact on U.S. international competitiveness.

Regulatory Policies

Three regulatory issues were of primary concern for survey respondents. These, and the respondents' assessment of their relative importance, are shown in Table 7. While regulation has often been cited as a burden on overall U.S. business competitiveness, a majority of those surveyed believe that government regulation does not have a critical effect on the ability of R&D to enhance the nation's competitiveness for each of the issues described. Less than a quarter of the businesses find any of the three regulatory issues to be of strategic importance to their firms.

Obviously, individual respondents within selected states, industries or universities may view this situation differently because of the impact that regulation may have on their particular organizations. This is also true when respondents considered the effect that certain regulatory activities might have on the economy at large. For example, when respondents considered the latter they viewed the regulation of new technology as considerably more important, with nearly half the university officials believing regulation to be a critical impediment to maintaining the U.S. scientific advantage.

However, overall, regulation is not regarded as an insurmountable barrier to competitiveness. While this view may not be popular with some advocates of deregulation, it is a fact that none of the three groups surveyed believe that R&D is significantly disadvantaged by domestic regulation.

U.S. Trade Policies and Practices

Although trade figures improved at the end of 1987, the long-awaited reversal of the trade deficit has yet to begin in earnest, and the expanding gap between increasing imports and decreasing exports continues to worry observers (see Figure 5). While U.S. exports to the newly industrialized competitors in the Pacific rose somewhat, their exports to the United States skyrocketed (see Figure 6).

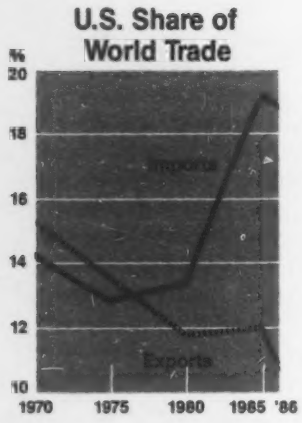
As the trade debate in Congress illustrates, there are numerous trade policies and strategies, as practiced by both U.S. and foreign governments, that can affect the competitive capability of U.S. business. After consulting with trade specialists, researchers identified four issues thought to be of primary importance to research and development. These, and the ratings survey respondents gave them, are shown in Table 8.

While only a minority of the businesses questioned view these issues as critically important to their individual firms,

Table 7: Regulatory Issues Affecting U.S. Competitiveness

Issue	*Business View: Critical to the Company/the Nation*		*University View: Critical to the University/the Nation*		*State Government View: Critical to the State/the Nation*	
Impact of regulatory reform on operations.	19%	58%	27%	35%	30%	30%
Regulation of new technology, e.g., biotechnology, etc.	18	39	12	41	24	40
Federal cost/benefit analysis for new technology.	10	16	8	23	5	8

Figure 5



Source: *Economic Road Maps*, Nos. 2013-2014. The Conference Board, November 1987.

Figure 6

Source: *Economic Road Maps*, Nos. 2013-2014. The Conference Board, November 1987.

on average more than half believe that all of these issues are critical to the overall economy. For example, only 17 percent of the business executives are critically affected by regulations regarding the export of newly developed U.S. technology. But more than twice that number believe that such policies critically impact the ability of the United States to compete with its trading partners. And, while slightly more than a quarter say that for their firms foreign trade barriers are of vital importance, nearly two-thirds believe that such practices are of critical importance to the United States as a whole.

As shown in Table 8, university officials—perhaps because they deal primarily in data—regard restrictions of transnational data flow with more concern than do business executives. Looking at the economy in general, university officials agree with industry that removing protectionist measures enacted by other countries is a key issue in improving U.S. competitiveness. State government officials tend to regard trade policy as much more important to their states', as well as the nation's, economic well-being than do their private sector counterparts.

Fiscal and Monetary Policy

Three issues were deemed of critical importance from a fiscal or monetary policy standpoint: the federal budget deficit, the tax treatment of R&D investments, and the value of the U.S. dollar. Opinions varied significantly as to how these issues affected individual firms versus the economy at large. Table 9 shows how business executives, university officers, and state government officials rated these issues with respect to their impact on the nation's economy.

More than half of the business leaders queried say that the federal budget deficit leads the list of fiscal or monetary issues restricting the United States' ability to compete with European or Asian competitors. Fewer than one in ten businesses ranked this issue of slight or no importance. Their views were echoed by university officers, with nearly three-quarters believing that the federal budget deficit is of major importance to competitiveness. State government officials were even more vehement in faulting the federal budget deficit for holding back the U.S. drive to remain internationally competitive. They consistently ranked this as the most important fiscal or monetary policy issue.

Nearly half believe that government treatment of R&D investment has a critically negative effect on the ability of the United States to remain competitive. The value of the U.S. dollar overseas, while important to efforts of U.S. business to export, was not given as much weight by respondents as the federal budget deficit and tax policy. On average, only a third of the respondents believe this issue to be critically significant.

The Targeting Controversy

Certain international competitors, Japan in particular, are said to engage in a competitive strategy referred to as "targeting." A few years ago the same type of activity, or a more generalized variation of it, was referred to as "industrial planning," "industrial policy," and so on. In essence, the concept involves a conscious decision by business and government authorities, acting in concert, to focus on the development of certain technologies or industries. This focusing can—and has—involved the granting of government subsidies to such industries, the erecting of tariff or nontariff barriers to protect domestic producers, the shifting of technical resources and financial support, and the designing of a variety of other steps to protect the chosen industries.

The Conference Board has previously conducted studies dealing with various trade and protectionist issues and has monitored and compared business and government sentiment on this issue over time. This study finds growing support in the United States for a limited use of the targeting strategy. While business leaders—and a majority of university officials—continue to regard economic planning as an anathema and voice opposition to any government-planned economic activity, they do show growing support for the concept that certain states might adopt, albeit on a de facto basis, an economic development strategy based on targeting principles. Even as this practice spreads, there is still concern that targeting decisions will be made for political, not economic, reasons.

Commentators recognize that certain states and regions have natural resource bases or certain distinct technological advantages and that it is reasonable to build on these assets. In California and Massachusetts, for example, as well as in Texas and several other states, there is already a strong electronics industry. In Michigan and the Midwest there have been significant gains in CAD/CAM and robotics. In New Jersey there are research and manufacturing skills in ceramics and sophisticated construction materials as well as in communications technology.

These states, their industries, and their universities are making a concentrated effort, through targeted R&D, to build on these bases. At the same time, other states are realizing that it makes little sense to duplicate their sister states' R&D targets and are, instead, looking for niches where they have a unique resource or technology advantage and are directing their R&D investments to such sectors. (An expanded discussion of this issue appears in the chapter "Regional Observations," pages 25 to 32.)

Table 8: Key Trade Policies Affecting U.S. Competitiveness
Percentage of Respondents Viewing Issue as of Critical Importance

Issue	*Business View: Critical to the Company/the Nation*		*University View: Critical to the University/the Nation*		*State Government View: Critical to the State/the Nation*	
Targeting, by foreign governments, of certain technologies.	29%	67%	7%	56%	32%	60%
Trade protection, by other countries, of certain domestic industries.	27	60	4	53	52	65
Export control of U.S. technology and products.	17	40	22	51	33	46
Control of transnational data flow.	12	29	15	43	26	43

Table 9: Fiscal and Monetary Issues Affecting U.S. Competitiveness
Percent of Respondents Viewing Issue as of Critical Importance

Issue	*Business View: Critical to the Company/the Nation*		*University View: Critical to the University/the Nation*		*State Government View: Critical to the State/the Nation*	
Impact on federal budget deficit.	28%	58%	39%	71%	57%	78%
Tax policy on treatment of R&D investments.	31	49	16	51	41	65
Value of U.S. currency in world markets.	31	45	6	51	30	43

Chapter 5

Ranking the Issues

Which of the six major issue areas covered in Chapters 1 through 4 has the most significant implications for improving U.S. competitiveness, for both an individual firm and for the economy? Table 10 shows how business executives voted.

With a few exceptions, the business executives surveyed ranked the issue groups in the same order as university and government officials. As shown in Table 10, educational and human resources issues are seen as paramount in terms of both the individual firm's and the nation's competitiveness. University officers weighed the same issues and their rankings are shown in Table 11, which, for comparative purposes, uses the same tabular listing as the business respondents' listing.

The state officials' ranking, as shown in Table 12, is somewhat different from that of their university counterparts. With the exception of state officials ranking technology transfer higher than do business executives, there is remarkable agreement between state and business executives on the issues. All three groups tend to value education and human resources policies and practices most highly as mechanisms for competitiveness.

Table 10: Key Issues
Overall Ranking, by Business Executives

Issue Group	*Rank Importance to Firm's Competitiveness*	*Rank Importance to Nation's Competitiveness*
Educational and human resources policies and practices.	1	1
R&D resources.	2	3
Fiscal and monetary policy.	3	2
U.S. trade policy and practice.	4	4
Federal regulatory policy.	5	5
Transfer of technology.	6	6

Table 11: Key Issues
Overall Ranking, by University Officers

Issue Group	*Rank Importance to University's Competitiveness*	*Rank Importance to Nation's Competitiveness*
Educational and human resources policies and practices.	2	1
R&D resources.	1	6
Fiscal and monetary policy.	5	2
U.S. trade policy and practice.	6	4
Federal regulatory policy.	3	3
Transfer of technology.	4	5

Table 12: Key Issues
Overall Ranking, by State Government Officials

Issue Group	*Rank Importance to State's Competitiveness*	*Rank Importance to Nation's Competitiveness*
Educational and human resources policies and practices.	1	1
R&D resources.	2	3
Fiscal and monetary policy.	3	2
U.S. trade policy and practice.	4	4
Federal regulatory policy.	6	6
Transfer of technology.	5	5

The view that education and human resources development is the key to the nation's future competitiveness was reiterated at the regional meetings. "The only truly durable response to competitiveness is education," said one chemical company executive. "All other things must follow it. Even innovation and R&D cannot last long without a good base in education."

The meeting attendees were somewhat puzzled by the low ranking given to technology transfer by the survey respondents. It received the lowest ranking in terms of its importance to U.S. competitiveness in comparison with human resources, R&D resources, and federal fiscal, trade, and regulatory policies. While 62 percent of the business respondents ranked human resources as one of the top two issues affecting competitiveness and 40 percent ranked research and development resources as critical factors, only 12 percent ranked technology transfer as one of the top two issues affecting U.S. competitiveness.

The university respondents also gave human resources the top ranking, relative to the nation's competitiveness, out of the six topic areas. State officials similarly ranked human resources as the most significant factor affecting competitiveness, but also ranked U.S. trade and fiscal policy higher than technology transfer.

These results are somewhat surprising given the commonly accepted wisdom that it is in the area of commercialization that the United States falls behind its major competitors. Several meeting participants said they disagreed with the survey findings on this point, indicating that they felt technology transfer was of crucial importance to the nation's competitiveness.

One explanation for the low ranking given to technology transfer may lie in the definition of the term. While technology transfer may be used in a very general sense to refer to the entire process by which a product or service goes from the idea stage to commercial application, the term can also be defined more narrowly to refer to the transfer of information from researchers to users. It should be kept in mind that the business executives responding to the survey are vice presidents for research and development, individuals likely to be more concerned about R&D resources (and having access to skilled engineers and scientists) than about transferring new technologies to the production process.

Several of the meeting participants made a further distinction in terminology, saying U.S. industry has not had a major problem with commercialization (bringing a product to market). Rather, competitive problems have involved production and marketing—being able to produce a high-quality product at a competitive price.

The executive of a major midwestern company commented: "The nature of the problem clearly has to do with our implementation. Where we have fallen down is in the quality of implementation, the cost of implementation, and the approach to continous improvement as our competitors have relentlessly moved forward."

Chapter 6

State Assistance Programs

Researchers from The Conference Board and the National Governors' Association identified 21 separate programs that states and universities use to assist or foster R&D in the private sector. The survey sought to determine how interested and aware business and university leaders were of these programs, the extent to which they had participated in them, and how valuable they were. Table 13 shows, in rank order, the ten programs of most interest to business and university officials.

Naturally, perspectives vary between industry and university officials as to what assistance measures most benefit their institutions. What is interesting is not the degree of variance, but the similarity in views on several key topics. For example, industry/university joint research projects are highly valued by both university and industry officials and both rate student internships or cooperative programs as the second most valued assistance program. Both groups also give matching grants for R&D and state libraries and data bases high marks. Table 14 shows how university officials rank the ten programs they view as most valuable to their R&D programs.

Table 13:
State Assistance Programs of Most Interest to Business Executives and University Officers

State Initiative/ Program Description	*Business Ranking*	*University Ranking*
Industry/university joint research projects.	1	3
Student internships or co-op programs.	2	2
Matching grants for R&D policy.	3	4
State R&D tax credits.	4	20
State libraries and data bases.	5	5
Skills retraining for production, technical or research staff.	6	11
Instructional and research equipment donations to universities.	7	1
Investment capital for facilities, machinery and equipment.	8	7
Funds for product development, testing, prototypes, etc.	9	16
Industry/university personnel exchange programs.	10	6

Table 14:
The Ten State Assistance Programs Seen as Most Valuable to University R&D Programs

State Initiative/Program Description	*University Ranking*
Instructional and research equipment donations to universities.	1
Student internships or co-op programs.	2
Industry/university joint research projects.	3
Matching grants for R&D.	4
State libraries and data bases.	5
Industry/university personnel exchange programs.	6
Investment capital for facilities, machinery and equipment.	7
Bond issues to support state R&D and education initiatives.	8
Technical data services (on faculty research, venture opportunities, etc.).	9
Start-up, venture or seed capital.	10

Table 15:
Percentage of Those Using the Most Popular State Assistance Programs

State Initiative/ Program Description	*Businesses Using*	*Universities Using*
Industry/university joint research projects.	62%	57%
Student internships or co-op programs.	62	78
Instructional and research equipment donations to universities.	50	75
State libraries and data services.	35	51
Matching grants for R&D.	24	56

The Most Frequently Used Assistance Programs

Table 15 provides the five most frequently used state programs and the percentage of the surveyed business and university groups who have actually used them. The survey data also show which programs or intitiatives are *least* likely to be used by industry. For example, less than one in ten firms use programs such as state patent and licensing services, the pooling of regional research resources, incubator start-up facilities or state liaison for access to federal labs. However, some programs, such as the provision of funds for product development, scored high in business interest, even though only one in twenty firms had ever used such aid.

For universities, some of the least-used programs include R&D tax credits (most often these are not applicable), state patent and licensing services, and site location assistance. And, while university parks have received a great deal of publicity as a mechanism for joint industry/university R&D participation, only one in eight of the universities surveyed has had any experience with such parks.

Which Programs Get the Highest Marks?

The survey asked both businesses and university officials to assess the programs they had direct experience with and to rate them in terms of their effectiveness in promoting R&D efforts. The top five programs are shown in Table 16. The top four programs, in terms of effectiveness, are virtually identical between the two groups, confirming the earlier observations about the degree of unanimity between university and industrial research executives over which programs they are most interested in, which they make greatest use of, and which are most effective in achieving their goals.

The state officials surveyed were asked to indicate how critical they felt the need for each type of program to be. By and large, their rankings of need were much higher than those of business. Almost three-fourths of the state respondents believe there is a strong need for both venture capital programs and technology extension services. Other programs that received high rankings by the state officials include science parks, investment capital, need for access to the work of federal labs, site location assistance, and incubators. Once again, the program perceived as least important, although 42 percent of the state respondents believe it is needed, was patent assistance.

The Smaller Companies

In part, the differences in the perceptions of the state, industry and university respondents in terms of the need for various programs can be explained by the fact that most programs are not targeted toward the larger, well-established firms who comprise the majority of the survey respondents. Most state programs are designed to serve the technological innovator or entrepreneur and very small businesses (often with fewer than ten employees). To assess the effectiveness of these services, surveys were sent to 700 small firms in six selected states. An insufficient number of responses were received from this sample to provide reportable results for most questions, with the exception of state assistance programs.

The survey data for all firms within the six states were broken down by size of firm, using less than 500 employees as one category and 500 or more employees as the other. Analysis showed that firms with less than 500 employees have a generally higher level of interest in the state programs than do larger companies (Tables 17 and 18).

State Programs that Bridge the Gap

As noted, the survey respondents were asked whether they were aware of the various state technical programs, whether they had used them, and what their assessment of these programs was. Although 13 states had reported operating *patent assistance programs*, only 9 percent of the industry respondents were aware of such programs and less than 1 percent had used them.

Table 16:
The Most Effective Assistance Programs in Promoting R&D

State Initiative/ Program Description	*Business Ranking*	*University Ranking*
Student internship or co-op programs.	1	2
Industry/university joint research projects.	2	3
Instructional and research equipment donations to universities.	3	1
Matching grants for R&D.	4	4
Skills retraining for production, technical or research staff.	5	8

Table 17: Financial Assistance Programs
Percentage of Businesses Indicating a High Degree of Interest in Program by Size of Firm

Program	Less than 500 Employees	500 or more Employees
Start-up, venture or seed capital.	40%	26%
Funds for product development, testing, prototypes, etc.	54	31
Investment capital for facilities, machinery, and equipment.	54	30

Table 18: Non-Financial Assistance Programs
Percentage of Businesses Indicating a High Degree of Interest in Program by Size of Firm

Program	Less than 500 Employees	500 or more Employees
State libraries and data bases.	48%	32%
Technical data services (on faculty research, venture opportunities, etc.).	36	30
Research and science parks.	29	28
Pooling of regional research resources.	14	26
Technical consulting services (feasibility studies, product testing, prototype development).	28	25
"Incubator" facilities for start-up firms (low rent office/lab space).	38	22
State liaison to provide access to federal laboratory and research facilities.	16	23
Site location assistance for R&D facilities.	13	18
Technical extension services (state field staff who provide technical advice and support).	24	12
State assistance and licensing assistance services.	20	11

Technical consulting services are provided in 17 states, but less than one-third of the businesses in these states are aware of them and only 19 percent had used them. They received a relatively low evaluation from both industry and universities. For the most part, the size of the firm responding to the survey indicates that they would not need such services, having access to on-staff technical expertise.

The same is probably true of the use of *technical extension services*, programs now operating in 25 states. While 26 percent of the businesses questioned were aware of these programs, only 9 percent had used them. These services received a low ranking by 35 percent of the businesses. On the other hand, 73 percent of the state officials ranked technical extension services as highly effective. Once again, these services are designed to assist small- and medium-sized companies and are less likely to be of interest or of use to large corporations.

Less than half of the business and slightly more than half of the university respondents were aware of state *libraries and data bases* or had used them. Thirty-six percent of the industry respondents and 65 percent of the university respondents who had used such facilities or services rate them highly in terms of effectiveness. Although 14 states report programs to *increase access to federal laboratories*, only 13 percent of the business respondents and 23 percent of the university respondents were aware of them.

Sixty-six percent of the university respondents ranked state *venture capital programs* as effective, as did 37 percent of the businesses and 42 percent of the state officials. Only 8 percent of the businesses had actually used state venture capital programs. The state officials ranked their states' *product development funds* as slightly more effective than venture capital funds, but 30 percent of the businesses surveyed rank product development funds as very low in effectiveness.

State *location assistance, science parks* and *incubators* were viewed as more effective by state officials than by business officials. Once again, this can probably be explained in part by the size of the responding firms. The data also seem to indicate, however, that additional outreach is needed to ensure that both business and university researchers are aware of the available services.

Chapter 7

Regional Observations

The data provided by survey respondents were broken down by state and region and combined with the commentary and presentations from the various regional meetings. Thus it was possible to identify issues of importance in four separate regional areas: Pacific Coast-Rocky Mountain, New England-Middle Atlantic, South-Southeast, and Midwest.

The tabular materials that follow illustrate the issues and ideas important to the respondents in each region and provide readers with an opportunity to compare the interests of the regions.

Ways Universities Can Assist Business

Universities in the four regions responded with a variety of suggestions on how they could best assist the business community in improving its R&D programs. The principal ways described are shown in Table 19. The universities were also asked how they thought business could assist them in improving university R&D programs; the principal ways cited are shown in Table 20.

Table 19: Ways Universities Believe They Can Assist Business R&D Efforts

	Regional Responses			
Method	*Pacific Coast-Rocky Mountain*	*New England-Middle Atlantic*	*Southern-Southeast*	*Midwest*
1. Helping transfer the latest technological advances into commercial applications.	X	X	X	X
2. Providing the basic research underpinnings to industry R&D programs.	X	—	X	X
3. Increasing the quantity and quality of scientists and engineers.	X	X	X	X
4. Lending faculty consultants.	X	—	X	X
5. Participating in joint research projects.	—	X	X	X
6. Broadening the research base within the regions.	—	—	X	X
7. Using students to gather preliminary data basic to various research projects.	—	—	X	X
8. Contracting for technical feasibility studies.	—	X	—	—
9. Providing on-site graduate programs tailored to industry needs.	—	X	—	—
10. Supporting technical extension programs aimed at industry.	—	X	—	—
11. Acting as subcontractors for some portions of industry's R&D needs.	X	—	—	—

Business and Universities: Business Perspective

To obtain the business community's views, executives were asked to rank the most important ways the university community can assist business R&D efforts. The responses fall into a pattern that suggests universities serve best, in business' view, when they do well those things they are primarily chartered to accomplish. Table 21 illustrates the business community's responses.

Business respondents also volunteered comments about certain aspects of the industry/university connection they found troubling. For example, one executive of a high technology company in Oregon observes that: "University professors should be more serious. They tend to charge high consulting fees and then delegate the work they have contracted for to graduate students. There is very little continuity possible in such arrangements."

Table 20: Ways Universities Believe Business Can Assist University R&D Efforts

	Regional Responses			
Method	*Pacific Coast-Rocky Mountain*	*New England-Middle Atlantic*	*Southern-Southeast*	*Midwest*
1. Providing or sharing advanced, state-of-the-art technical equipment.	X	X	X	X
2. Providing financial aid targeted at R&D ventures.	X	X	X	X
3. Participating in joint R&D ventures.	X	X	X	X
4. Providing industry scientists to serve as adjunct professors.	X	X	X	X
5. Implementing student and faculty internship programs in industry.	—	—	X	X
6. Supporting the creation of R&D parks.	—	—	X	—
7. Participating with consultative advice on curriculum development for science and engineering curricula.	—	—	X	—
8. Supplementing student and faculty internship programs in industry.	X	—	—	—
9. Cooperating and participating in research colloquia and symposia.	—	—	—	X

Table 21: Ways Business Believes Universities Can Assist Business R&D Efforts

	Regional Responses			
Method	*Pacific Coast-Rocky Mountain*	*New England-Middle Atlantic*	*Southern-Southeast*	*Midwest*
1. Providing a ready and highly qualified supply of scientists and engineers.	X	X	X	X
2. Performing basic research.	X	X	X	X
3. Participating in joint research projects.	X	—	X	X
4. Preparing students to enter the workforce by teaching them workforce disciplines.	—	—	X	X
5. Providing on-the-job degree programs.	—	X	—	—
6. Providing timely dissemination of data on research breakthroughs.	—	X	—	—
7. Allowing small companies access to high-cost laboratory facilities.	—	X	—	—

Some business executives think that university researchers fail to consider the possible commercial applications of their work. A California executive complains: "Universities, particularly state universities, need to be much more involved with typical industrial (R&D) problems so that when they face a decision point they can take a path that may have a solution to an industrial problem at the end." And an executive of a high technology company in New Jersey observes: "Universities could be of more aid if they concentrated on real world problems. They should establish programs that put a premium on highlighting a critical evaluation of research results and avoid textbook answers to technical problems."

A manufacturer in Iowa says, "Universities should be more willing to research problems of interest and concern to industry rather than simply applying for support to study ideas that are only of interest to the university." An Illinois manufacturer wished that "universities would make it possible for small companies to benefit from university research—while maintaining the confidentiality needed for small business survival in highly competitive markets." One company executive in Virginia adds, "Universities should concentrate on increasing the product development skills of engineers and scientists in our area. For example, we don't need as much basic research on material and construction as we do developmental input on the application of these materials."

An executive of a Connecticut-based company believes that "universities should avoid over-specialization in narrow disciplines." And one from a New York firm suggests that universities would "do better to seek flexible funding from many sources rather than concentrating on single-source support." An Alabama exeuctive wishes that universities would "do a better job of motivating students," noting that "it's vital that students be properly prepared for the world of work."

But, in general, the regions' businesses gave universities high marks and want to expand industry/university linkages. An executive of an electronics firm in Indiana points out, "The major role of universities is to serve as a resource in emerging technologies. We don't expect university labs to solve our short-term problems. But on-going communication between industry's senior researchers and their university colleagues serves to broaden our technology base and to define intermediate- to long-range projects."

And a Colorado building products company representative believes business must rely on universities, stating, "[We need] contract research services in fundamental areas in which the universities have expertise—and we have the least knowledge." A West Virginia resources company executive endorses this view and adds, "We need universities to conduct the basic research that is vital to our development during the next ten years. Industry should provide some of the funding as well as some of the guidance."

Business Aid to University R&D

Industry has its own ideas about how it can best assist university-based R&D. Often there is a striking degree of agreement with the views expressed by university spokesmen. The primary ways are described in Table 22. Several firms surveyed in North Carolina, Georgia and Florida suggest that business might also aid universities through exploratory research that augments business efforts."

Northeastern companies suggest that business could bring a "market perspective" to some of the colleges' R&D projects. A Pennsylvania executive thought one way business could help would be by participating—with other businesses—in an "interim review of various university research projects." The firms were careful to stress that their role would be strictly advisory and that university researchers need to hear such advice.

Table 22: Ways Business Believes It Can Assist University R&D Programs

	Regional Responses			
Method	*Pacific Coast-Rocky Mountain*	*New England-Middle Atlantic*	*Southern-Southeast*	*Midwest*
1. Participating in student cooperative programs.	X	X	X	X
2. Providing staff members to serve as adjunct faculty.	X	X	—	X
3. Donating funds and equipment to university laboratories.	X	X	X	—
4. Helping to build the science education infrastructure.	X	X	X	X
5. Establishing strong communication channels between industry and university laboratories.	—	—	—	X

A Washington executive opted for a more hands-on approach. "We are 'applications-oriented.' We can help university engineering departments stay in a practical venue." And a respondent from a small Oregon electronics firm believes his firm could provide both equipment and advice, volunteering, "We could help by providing technical equipment at reasonable prices and specific 'real world' guidance on problem priorities."

In some instances executives believe university researchers are ill-equipped to decide what technologies will be the most commercially significant. A number of executives in Michigan, Missouri and Minnesota suggest business could also aid universities by "having industry provide insights into what is commercially feasible and which projects have the most likely commercial payout."

Aid from Government

Both business and university executives suggested a catalog of measures that the government could use to foster U.S. technological innovation. State officials in the regions added their views as well. The inventory of suggestions appears in Table 23.

A minority of respondents would simply prefer to see government "get out of the way." One South Carolina manufacturer says, "Sometimes government unnecessarily complicates business decision-making because of its vacillation on regulation—be it tax rules or environmental controls. This uncertainty leaves executives in a neutral position, undecided which way to go."

Most business and university respondents believe both state and federal governments have a significant role to play by providing a tax structure that provides incentives for R&D and by supporting basic research programs. At the same time, state government officials are interested and concerned with the equity and impact of state aid on local R&D, as well as the role that federal aid plays in assisting the R&D efforts of their states' firms. An Arkansas state official thinks the federal government should "help support high-risk state programs and take steps to move toward more geographic parity in assistance programs to universities in our region."

An Oregon official cautions, "There is a significant 'free-rider' issue involved when the technology developed at the expense of one state's taxpayers benefits businesses in another state." But others surveyed tend to take a less restrictive view, subscribing to the notion that new technology developed

Table 23: Ways Government Can Assist R&D Efforts

	Regional Responses			
Method	*Pacific Coast-Rocky Mountain*	*New England-Middle Atlantic*	*Southern-Southeast*	*Midwest*
1. Increasing R&D tax credits to foster R&D investments.	X	X	X	X
2. Increasing the proportion, as well as the total, of funds devoted to supporting civilian sector basic research.	X	X	X	X
3. Providing greater parity between geographic areas in terms of federal support for basic research.	X	X	X	X
4. Facilitating the transfer of technology from federally supported university or national research laboratories to industry application development programs.	X	X	X	X
5. Improving science education at the secondary school level through a variety of federal and state incentive and aid programs.	X	X	X	X
6. Providing increased support for science and engineering equipment grants.	—	—	X	X
7. Restricting imports in high-tech leading-edge industry sectors.	—	—	X	X
8. Reducing the government bureaucracy involved in the nation's R&D efforts.	X	X	—	—

within their states inevitably generates jobs and business far in excess of the individual states' investment costs.

Another state spokesman believes that the federal government should take further steps, through tax regulation, to "discourage investments in nonproductive, essentially shelter-type investments and to lead investors towards investment in R&D ventures."

Some of the respondents would prefer to see government more active in promoting broad science objectives. A New Jersey company executive suggests an expanded educational role with government helping to educate the public to "the critical importance of successful science and technology efforts in the advancement of national living standards." The vice president of research for a Missouri manufacturer said, "Unless we start with the fundamental problem—education—all other steps will simply be a 'quick fix' solution. We have to begin with the basics."

Some respondents think government can help most by removing what they perceive to be government-erected barriers to effective R&D. A Wisconsin official thinks that the federal government could best help by "eliminating the antitrust barriers and other legal hurdles that bar greater cooperative research programs and by increasing the tax deductions available for donations to support university research programs." A New Jersey executive believes the government should "clarify the regulatory position on issues such as biotechnology, so that industry can make rational risk/benefit decisions."

Targeting Technologies Within States

As previously noted, one of the strategies suggested for states to pursue in assisting R&D programs is to target certain technologies—in effect, to stake out technological turf and to concentrate on assisting those industries and research programs that fall within the target circle.

Many industry and university officials reject such a strategy. The arguments they offer are quite similar and may prove instructive for those who would construct a policy based on such concepts. For example, a Virginia manufacturer declares: "There is no evidence such government intervention will prove helpful. Often, government follows industry in focusing on particular industrial opportunities." An executive of a software firm in Oregon argues: "Targeting isn't the most important strategy—education is. Concentrations of like industries do advance the art faster than widespread research units, but primarily because there are pools of talent in such areas and they reach a necessary critical mass."

Several firms in each of the regions were distrustful of the ability of either state or federal government officials to implement a targeting strategy fairly—even if one could be devised. One executive of a Washington state corporation rejects the notion because "the support for a particular industry or technology becomes based on politics rather than economics." A spokesman for another west coast firm, a small electronics company, believes: "States are very inefficient at this [targeting]. The federal government is more likely to see the 'big picture' a lot better." But even this approach may not be effective, the firm's president concedes.

The vice president of research for one of California's major firms considered the targeting strategy option and decided: "Targeting should not exclude other technologies. Concentrating on a single technology limits innovative research in other areas in which industries or universities within the state may have the potential for developing something new."

Some believe that targeting might not be coordinated and would result in duplication of effort. A California company executive points out: "We need real centers of excellence in a range of technologies. But, if every state established a center in silicon technology, it would likely decrease our national competitiveness."

A representative of a robotics company in Massachusetts argues, "A targeting policy would lead to 'trade barriers' between the states and the U.S. would soon look like the EEC." Another company executive from New England "seriously doubts the abilities of states to pick 'good technology.' "

In Illinois, a manufacturer states, "Targeting just fosters the spirit of economic isolationism in the U.S." Another, from the same state, points out, "As a practice it seems rational for states to target technology. But as a coherent policy it smacks too much of a planned state economy."

There was, however, some support for the concept of targeting. An executive of a Florida-based firm believes targeting might work if high performance standards were developed to review projects that might benefit from targeting strategies. A Kentucky company executive thought such a strategy might work in those cases where certain states have special advantages because of their natural or industry-based resources.

Dealing with Shortages of Technical Personnel

While there are differences of opinion over the existence and extent of technical personnel shortages, most surveyed believe the nation suffers from a shortage of qualified engineers, scientists and technicians. The respondents have suggested various remedies, and these are shown in Table 24.

As a general proposition, respondents from both the business and university communities believe market forces—principally higher salaries for science teachers, as well as for scientists, engineers and technicians—will help solve the shortage issue in the long run. State officials agreed with this assessment, and the science and technology advisor in one state noted wryly, "If we [business and universities] provide jobs for them in our state now, we won't have to try to recruit them back later from other states."

Nonetheless, they are concerned that in the next decade many industries will face critical shortfalls in the supply of technical personnel. A Massachusetts company executive reports: "The supply of scientists is tight enough now. We can't imagine what it is going to be like in ten years."

Barriers to Innovation

The study participants took a close look at what they regard as the most significant barriers to innovation. Business, university and state officials responded by first describing the barriers they consider basic to the national situation and then focusing on barriers that seem to have particular relevance for their regions. Some of the impediments that they regard as systemic to the nation include those shown in Table 25. Table 26 illustrates the barriers of special concern to the selected regions as seen by business and academia. Table 27 illustrates a somewhat different group of barriers selected by state officials in each region.

Additional Steps to Foster Joint Ventures

The survey respondents were asked to suggest steps that could be taken to encourage the growth of industry/university R&D ventures in their regions. The principal suggestions are shown in Table 28.

Several respondents described the difficulties associated with starting joint ventures. A Virginia executive points out: "The steps to date [in our area] have been fumbling or staggering. Sounder project management is required in order to assure success and also to convince others that such ventures are not a wash." An Oregon university official believes that "joint R&D projects should only take place if they are to be well-coordinated and the sponsors do not interfere with the ability of the researchers to pursue the goals of the project."

A New Jersey company executive reminded researchers, "When public dollars are used, you cannot restrict access to proprietary data developed in the research venture. Industry wants such restrictions and patents in order to give it a competitive edge."

One northeast manufacturer volunteered that it was generally opposed to joint ventures between competing companies because "such arrangements tend to retard the introduction of new technology to the marketplace." This same theme was found in other regional responses. For example, a representative of a Washington-based company believes, "Joint R&D ventures, particularly between competing companies, are often very difficult...and potentially illegal. It might be possible for the government to establish university R&D funds that could be spent investigating specific areas of interest to industry. In such scenarios industry would, to a limited extent, be involved in directing the research effort."

Table 24: Suggested Ways of Relieving the Shortage of Technical Personnel

	Regional Responses			
Method	*Pacific Coast-Rocky Mountain*	*New England-Middle Atlantic*	*Southern-Southeast*	*Midwest*
1. Improving the quality and availability of science teachers in the K-12 grades by increasing salary levels.	X	X	X	X
2. Expanding financial assistance to undergraduate students majoring in science and engineering.	X	X	X	X
3. Promoting the economic advantage of science and engineering education by advertising the availability of related jobs in the private sector.	X	X	X	X
4. Focusing more attention in universities on the teaching-skills component of undergraduate science and engineering education.	—	—	X	X
5. Improving the ability of guidance counselors to provide direction to college-bound high school seniors.	—	X	—	—
6. Providing special scholarships for science teachers-in-training.	—	X	—	—
7. Providing security of employment to scientists.	—	X	—	—
8. Subsidizing Ph.D. candidates in science and engineering who agree to teach for a two- to three-year period after graduation.	—	—	—	X

Table 25: Systemic Barriers to Nationwide Innovation

Barrier	Regional Responses: Pacific Coast-Rocky Mountain	New England-Middle Atlantic	Southern-Southeast	Midwest
1. A lack of long-term goals and viewpoints on the part of corporate leaders.	X	X	X	X
2. An unwillingness to invest in longer term R&D ventures, coupled with a lack of related tax incentives.	X	X	X	X
3. An inadequate reward structure to encourage research scientists to transfer their new technology to commercial products.	X	X	X	X
4. A national deficit in mathematics and science preparation at the secondary school level.	X	X	X	X
5. Outmoded, obsolete R&D equipment and facilities at the university R&D level.	X	—	X	X
6. Difficulties in matching capital to small creative enterprises.	—	—	X	—
7. Proprietary trade secrets within U.S. industry.	—	—	X	—
8. An imbalance in the support provided military-market R&D as opposed to civilian sector research.	—	X	—	—

Table 26: Regional Barriers to Innovation as Seen by Business and Academia

Barrier	Regional Responses: Pacific Coast-Rocky Mountain	New England-Middle Atlantic	Southern-Southeast	Midwest
1. A lack of international business skills.	X	—	X	—
2. A lack of advanced managerial skills.	X	X	X	—
3. A shortage of sophisticated technologies in manufacturing.	X	X	X	X
4. The lack of intellectual property protection.	X	—	X	X
5. Shortages of risk capital.	X	X	X	X
6. Inattention to timeliness in R&D and to quality in manufacturing.	X	X	X	—
7. A lack of appreciation for the benefits of automation.	X	—	X	—
8. The excessive costs of product development and testing.	—	—	—	—
9. Aggressive foreign competition, especially from Asian producers.	X	X	—	—
10. An unfavorable tax climate for R&D investments.	—	—	—	X
11. Poor profitability prospects for technological investments.	—	—	—	X

Another executive from a west coast firm echoed the same sentiments and suggests: "Government might provide funds for industry/university consortiums that would focus on developing new ideas without strict adherence to time scheduling and project costs... ideas that would, by their nature, emphasize high-risk types of research projects."

In general, the university respondents were cautious about the nature of the process and how it would be managed. An official at a midwestern engineering college says that "fostering cooperation among competitors can be tantamount to state-sanctioned monopolies, and should not be encouraged." But at the same time the overall view is that in a period of intense international competition the United States cannot afford the luxury of rejecting any possible device to promote R&D and that cooperative research is one such important device.

Table 27: Barriers to Innovation in the Regions as Seen by State Officials in Each Region

	Regional Responses			
Barrier	*Pacific Coast-Rocky Mountain*	*New England-Middle Atlantic*	*Southern-Southeast*	*Midwest*
1. A lack of venture capital in the region.	X	—	X	X
2. High personal and corporate income tax rates.	X	—	X	X
3. A propensity towards excessive regulation of technical ventures.	—	X	—	—
4. Inadequate pre-venture capital availability.	—	X	—	—
5. A traditional corporate orientation that is not conducive to, or supportive of, entrepreneurship.	—	X	—	—
6. Insufficient job opportunities for younger workers.	X	—	X	—
7. High structural unemployment from declining industries.	—	—	—	X
8. Lack of corporate research centers.	—	—	X	—

Table 28: Ways of Fostering Industry/University Joint Ventures

	Regional Responses			
Method	*Pacific Coast-Rocky Mountain*	*New England-Middle Atlantic*	*Southern-Southeast*	*Midwest*
1. Modify existing antitrust restrictions to encourage R&D joint ventures.	X	X	X	X
2. Expand the number of technology centers.	X	X	X	X
3. Increase the number of student internships.	X	X	X	X
4. Provide direct federal financial support for certain industry/university partnerships.	X	X	X	X
5. Establish multi-industry, multidisciplinary research parks.	—	—	X	—
6. Change laws to allow faculty members to take equity positions in R&D joint ventures.	—	—	X	X

Chapter 8

Conclusion

All three of the groups studied agree that attention must be paid to science and engineering research and education needs if the United States is to maintain a leading role in the international marketplace. Increased investment in research and education will be required to sustain a vigorous and advanced technological community in the face of increasing foreign competition.

The study participants identified a number of areas for improvement:

- *Science and mathematics education*. Greatest emphasis was placed on the need to develop and maintain an adequate supply of science, engineering and technical personnel. Preparation of elementary and secondary students in science and mathematics, and the supply of qualified teachers in these areas, is seen as matters of utmost concern.
- *Industry/university cooperative ventures*. These arrangements are viewed as critical to U.S. competitiveness by state government officials; less so by business and university participants. Survey respondents view this variance as a significant barrier to future effectiveness and believe these attitudes must change if cooperative ventures are to play a major role in supporting U.S. research and development.
- *More effective commercialization of research findings*. The time lag in the commercialization of new technology by industry puts the United States at a competitive disadvantage in the world market. Lack of access to federally sponsored research and clarification of policy on intellectual property rights are also considered significant factors in U.S. competitiveness.
- In addition, warnings were sounded regarding the *need to change the way Americans think about careers and retraining*. A technical education no longer lasts a lifetime.
- Finally, the *business community was faulted* by all three groups of participants *for lack of patience regarding long-term investments in product development*.

The regional analyses documented the foregoing conclusions and, in addition, looked closely at the nature of industry/university relations and discussed ways to expand these linkages. Participants in all three meetings—and survey respondents as well—agreed that both federal and state governments have a significant role to play in the changing nature of these relationships.

In addition to determining the views of business, state government, and university officials on research, education and competitiveness, the study raised a number of issues that merit further consideration. First, what actions should be taken to improve science and mathematics at the primary and secondary school levels? Second, demographic changes and a decline in the number of American students pursuing science and engineering degrees will require greater involvement by women and minorities in science and engineering. How is this to be achieved? Third, how can long time lags in the commercialization process be reduced? Fourth, industry/university partnerships should be evaluated and their performance tracked over time. What criteria should be used to judge their performance and their contribution to the generation and transfer of knowledge? Fifth, many of the respondents questioned the merit of state programs that target particular technologies and industries, a practice that is nonetheless becoming more widespread. Should these state programs be reexamined?

Lastly, future partnerships require redefinition. What is the relationship between state initiatives and federal efforts regarding research and development? Are state/federal partnerships needed, and if so, how should they be structured? How would a restructuring affect the private sector and the academic community? These are questions that must be addressed if the United States is to meet the growing economic challenge.

APPENDIX

Economic Competitiveness: Redefining Roles for Government, Industry and Universities

April, 1987

Speakers and Panelists

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Ohio State University

Warren Baker
President
California Polytechnic State University

Edward Barr
Chairman
N.J. Commission on Science and Technology

Michael Beug
Academic Dean
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Lynn Blake
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Elaine Bond
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Raymond Bye
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Kermit Campbell
Vice-President for Communications
and Public Affairs
Dow Corning Corporation

Dwight Carlson
President
Perception, Inc.

John F. D'Aprix
President
University City Science Center

John DiBiaggio
President
Michigan State University

Wayne Embrey
Deputy Director
Oregon Research and Technology
Development Corporation

Saul Fenster
President
New Jersey Institute of Technology

The Honorable Booth Gardner
Governor
State of Washington

William Gerberding
President
University of Washington

Robert Greenkorn
Vice-President for Research
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Robert Gross
Dean of Engineering
Columbia University

Burton Jonap
Vice-President
Connecticut Product Development Corporation

Bruce Kasson
Vice-President for Marketing and Customer Operations
Cray Research

The Honorable Thomas H. Kean
Governor
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David Kennedy
Program Administrator for Curriculum
Office of Superintendent of Public Instruction
State of Washington

David Longanecker
Executive Director
Minnesota Higher Education Coordinating Board

Walter Luscutoff
Executive Vice-President
Flow Industries

George Mackaness
President
Squibb Institute for Medical Research

Edith Martin
Vice-President for Technology
Boeing Company

E. Patrick McGuire
Executive Director
Corporate Relations
The Conference Board

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